SCHOOL SCIENCE AND MATHEMATICS

VOL. XXXIV, NO. 2 FEBRUARY, 1934 WHOLE NO. 292

A THOUGHT FOR MEMBERS OF THE CENTRAL ASSOCIATION

This issue contains the report of the 33rd Annual Convention of the Central Association of Science and Mathematics Teachers, and many of the papers read at that meeting. This two-day meeting was attended by classroom teachers from New York to Des Moines and from Minneapolis to St. Louis. The general sessions filled the Gold Room of the Congress Hotel and the section meetings taxed the capacity of adjoining convention rooms. The entire meeting was a testimonial of the fact that teachers of the basic sciences know the value of united effort and have the professional spirit that will insure progress even in the most critical educational period. The papers show a grasp of the fundamental problems confronting science education. You should read them all. Other papers from this meeting will follow in the next issue.

For each member present at this meeting there is a large number of teachers in each community who should be members. The profession needs their active support; but, what is more important to them, they need the Association. Many of the improvements in instruction in the basic sciences that have been made in the past thirty years have been due to the Association and its members. Every member should be a missionary for the Association in his own county or city. That community will soon recognize his leadership; it will check the attacks now being made on science instruction by selfish interests; it will demand that instruction in mathematics and in all the other basic sciences be extended rather than curtailed or eliminated. The way to get this public approval is to secure first the united

support of all teachers of these subjects. Get them into the Association. If they become regular readers of its journal they will get out of the rut and put new life into their teaching. In a scientific age no one should be allowed to remain ignorant of the basic principles of science.

ATTENTION! FELLOW SCIENCE TEACHERS

By John H. McClellan
Chairman Physics Section of the Central Association of Science and Mathematics Teachers

At a time when the nation is being made into a vast laboratory of the Social Sciences, when huge experiments in Economics, Sociology, Business Administration and Banking are being carried out upon a stupendous scale hitherto undreamed of, where do we science teachers find ourselves? We find ourselves burdened with greatly increased teaching load, lessened or no appropriations for laboratory equipment, and threatened elimination of our regular laboratory time. Is this the path of progress? Must our teaching of Physics and Chemistry in the future be confined to mere dogmatic memorization of facts, laws and formulae? Shall we confine our teaching largely to semi-obsolete facts within the pages of a textbook? Will we thus equip our students to cope with problems of a rapidly changing world? Will we not rather serve the new generation better by inculcating the scientific attitude that nothing is absolutely certain except death and change? Surely we need to emphasize that all of our conclusions must pass through the fire of experimental verification. No education should be considered adequate for the ordinary citizen which does not include individual laboratory work. Only by such experience can one come to an appreciation of the methods necessary for scientific progress. Dear fellow teacher will you not devote some time *now* to conscientiously answering the questionnaire found on page 221 of this issue?

EASTERN ASSOCIATION OF PHYSICS TEACHERS

This is the strongest local organization of physics teachers in the country. Their meetings are held three times a year and reports are published in this journal. The report of the 125th meeting, which was held at Arlington, Mass., Dec. 16, 1933, is on pages 193–206 of this issue.

THE THIRTY-THIRD CONVENTION OF THE CENTRAL ASSOCIATION OF SCIENCE AND MATHEMATICS TEACHERS AT CHICAGO, ILLINOIS, DECEMBER 1 AND 2, 1933

The Thirty-Third Annual Convention of the Central Association of Science and Mathematics Teachers met at Chicago, Illinois, Friday and Saturday, December 1 and 2, 1933, the President, Dr. Charles A. Stone, presiding at all sessions. All the meetings were held at the Congress Hotel which is admirably equipped to handle such a convention. The great success of this meeting coincides with the experience of the Association at Cleveland last year, where all the program was also held under the roof of one great hotel, and indicates that this method of handling the convention is not only more efficient but meets with the general approval of all those attending.

The Committee on Local Arrangements, headed by Dr. J. S. Georges, and the President of the Association, Dr. Charles A. Stone, had worked tirelessly with the Chairmen of the seven Sections to produce one of the most outstanding programs in the history of the Association. That their work was appreciated was evidenced by the large attendance and the fact that never before were there so many members in attendance from outside the city in which the convention was held. Hence it is fair to say that never has the attendance at one of our conventions been so representative of the entire membership as it was this year. This is just one of the many indications that came to light at this convention showing the excellent general health of the Central Association, which is all the more gratifying considering the present prevailing economic conditions. The reports of the Treasurer, Mr. E. S. Martin, of Indianapolis, and of the Business Manager of the Journal, Mr. W. F. Roecker, of Milwaukee, show the finances of the Association to be in excellent condition, a thriving state which is rare in these days.

The convention was preceded as it always is by a meeting of the Board of Directors and of the General and Sectional Officers on Thanksgiving evening. This was purely a business meeting.

FRIDAY MORNING GENERAL PROGRAM

The general program opened at 8:00 A.M. Friday in the lobby of the Gold Room with the registration. At 8:45 the members entered the Gold Room where they listened to a delightful program by the Glee Club of the Lane Technical High School, of Chicago, under the direction of Mr. Joseph R. Taylor. This musical entertainment was followed by a cordial welcome by Dr. William J. Bogan, Superintendent of Chicago Public Schools, who, among other things said:

SUPERINTENDENT BOGAN'S ADDRESS OF WELCOME

On behalf of the citizens of Chicago in general and the teachers in particular, I welcome you to our city. This welcome is genuine because the citizens are genuine by nature in their hospitality to friends and strangers.

It is sincere, because, notwithstanding some signs to the contrary, the people of Chicago have a sincere respect for those engaged in educating their children, and a sincere belief in the benefits that accrue to the individual and to society from a far-flung system of popular education. There is a trace of selfishness in this welcome to be sure, but this selfishness is complimentary to you, for Chicago appreciates the great benefits that you bring through conventions like this to her children. At the worst, this selfishness is vicarious. Its source does not lie directly in self but in self rather far removed—in the children.

To this welcome I attach a string bearing an important request. The criticism is often made that your group likes to dwell in the upper regions of secondary schools and colleges where the atmosphere is rare and pure, each member working in his own compartment without much reference to those in other compartments. The world believes that there is considerable justification for this criticism and it frequently asks that you come out of your compartments occasionally for the purpose of aiding the spread of science in the lower grades, to the end that pupils may learn to think. Surely, if science is the best agency for provoking thought it should be extended throughout all the grades. It is possible to fire youth with the burning glass of science and mathematics, provided they are not formalized unto death.

Upon the children and the youth of our land we build high hopes. We look with confidence to them for our salvation from the crime, the corruption, and the low morale of our day. Education is one of the few tools that will aid them in building a new and better civilization. Education is your special function. Therefore, we welcome you as prophets of the new order and trainers of a new race.

The response for the Association was given by Dr. J. S. Georges, of the Hirsch High School, Chicago, Chairman of the Local Arrangements Committee, who spoke as follows:

Response for the Association

It is an honor and a privilege to be permitted to respond for the association to the address of welcome by Mr. Bogan. For the cordial welcome he has extended to the delegates herein assembled we heartily thank him, and with a keen sense of duty we appreciate his exhortations. His heroic efforts, and those of our colleagues in the system of which he is the superintendent, in these trying times to uphold the standards of free public education have won the approbation and commendation of all the friends of public schools.

The 33rd convention of the Central Association of Science and Mathematics Teachers in Chicago is of special interest both to the city and the Association. This great city takes a unique pride in welcoming and honoring this Association as one of her own offsprings, for it was here some thirty years ago that the Association first came into being. In turn we of the Association are happy to celebrate with Chicago the Century of Progress, an occasion which brought to the attention of the world the greatness of this city as a center of scientific, religious, industrial, and educational accomplishments. The scientific progress has been more than astounding, and this Association feels happy to have been an instrument in the dissemination of scientific and educational knowledge.

The specific contributions of the association, as revealed by a thorough analysis of the issues of SCHOOL SCIENCE AND MATHEMATICS, the official organ of the Association, may be grouped for convenience into six major classes.

The first class deals with educational problems which have for their purpose the determination of the aims of instruction, the learning products associated with each specific course, and the definite objectives to be attained through the facilities of the classroom instruction. That real progress has been made in this specific educational field is evidenced by the fact that most of the courses offered both in sciences and in mathematics have undergone a transformation during the past thirty years, the lifetime of the Association.

In the second class we find reported results and findings of investigations and experiments to determine suitable instructional materials for the attainment of the instructional aims. The outcome of these investigations has been the elimination of difficult and undesirable materials, the modification of the existing materials, and the discovery of new materials better suited to facilitate learning, and to enhance the educational values of the specific courses.

In the third class we group the papers dealing with the organization of the instructional materials. As a result the traditional organization of the courses has almost disappeared from our curricula, and in its place we find new types of learning units, coherently welded together, centered about some significant concept, or process, gradually unfolding the major aspects of the subject and making them available as thought processes. The contributions of the members of the Association in this field have been strikingly significant.

Problems related to the methods and modes of instruction fall into the fourth class. The old methods have been scrutinized and have been subjected to critical tests. Modifications have been made in the light of scientific procedures. New plans and procedures have been suggested from time to time, and these suggestions have found a responsive and cooperative group in the members of the Association.

The evaluation of instruction forms the next class of problems. Tests have been devised to diagnose inherent and acquired inhibitions and difficulties, and remedial treatments have been set up to handle the special problem cases. Functional tests have been determined to evaluate the rationalization of the processes and the understanding of the concepts. Achievements tests have been formulated to measure the degree of accuracy and the rate of action in the manipulations of the processes, and in the acquisition of special skills. As a result the present day teaching is purposeful and definite, and the Association takes great pride in having been instrumental in furthering this educational undertaking.

The last class of papers are philosophical in character. The members who have had the advantages of specialization in the various sciences and mathematics have contributed freely in the interpretation of the intrinsic functions of the various subjects. The foundations of the subjects have been strengthened and the significance of the various concepts and principles have been made accessible to the class room teacher. This has in turn elevated the standards of instruction.

The success achieved in the celebration of a Century of Progress has inspired the civic leaders in the city of Chicago to go ahead. Plans have been formulated for a continuance of the project. Likewise it behooves the members of the Central Association of the Science and Mathematics Teachers to continue the marvelous progress accomplished in the past, and to continue the endeavors for the improvement of teaching. The Association was the culmination of an effort to coordinate the spheres of educational influence of the sciences and of mathematics. The achievements of the Association are a living testimonial, to the success of that undertaking.

However, in these times of universal curtailment of education it might be desirable for us to analyze if possible the factors responsible for such an attitude, and to determine our future course of action in the light of such an analysis. In spite of the specific improvement of the methods of instruction, the results are far from being satisfactory. If we judge our educational system by its products, then there is room for criticism. If we teach better now than we did in the past, and if our methods are more efficient than formerly, yet the graduates we are turning out do not live up to the requirements of educated people, then surely there is something radically wrong with our system. May it not be that we are going in the wrong direction, or that we have a wrong philosophy of education?

Our present system of education may well be called an individualized industrial system. It focuses the attention on the individual, and it promotes the development of the industrial capacities of the individual. He is diagnosed, instructed, tested, and trained to follow his individual and personal inclinations. The world owes him a living, and we teach him the tricks of a trade to go out and demand that living of the society. Of the social values of education, and the specific social aspects of the various courses and subjects we are either entirely unaware or if aware we do it incidentally.

This point of view has crept even into our teaching of the special subject. We teach, for example, addition, factoring, equation, etc., in algebra, and the student may be able to add, to factor, to solve equations, etc., but he does not know algebra. He has no idea of the real essence of algebra. He is totally ignorant of functionality, of transformations, of laws, of invariants, which are the genuine social aspects of algebra. Or we teach him, heat, sound, light, electricity, in physics, and he may know these topics well but be utterly lacking in scientific attitudes and procedures. It may be that we need a philosophy of education which makes the social functions primary, and the orientation of the individual to the social requirements the ultimate end of education.

You are familiar with the fact that Newton's laws of motion apply to a particle, an individual particle. The application of these laws to bodies, such as the planets, necessitates the consideration of these bodies as if they were particles, with their masses concentrated at their centroides. However, to develop a science of mechanics of bodies, homogeneous or nonhomogeneous, we modify Newton's laws in the light of a further assumption. We assume that the body is a sum of its particles. An innocent assumption, but it shifts the emphasis from the particle to the body. These modified laws of motion do not apply to a pile of sand, but they do apply to a rock. It is a different philosophy, but it works.

Suppose that the individual was made group conscious from the kindergarten up, and that his education consisted in social relationships, social requirements, and social adjustments, each subject contributing to the development of the necessary aptitudes, what would be the outcome? We can only surmise. But it is quite clear that we would have a different philosophy of education. Whether it would work or not would depend on our ability to formulate and develop consistent assumptions and laws.

If we subscribe to such an undertaking then we must enlarge the scope of our activities. We must coordinate our efforts with those of the educators in the field of social sciences. With our scientific training and experience we can be of help to them, and in turn they can formulate the problems and direct our united efforts toward the solution of our social problems. It is a huge undertaking, but the past accomplishments of this Association warrants the conclusion that it is worth trying.

Dr. Charles S. Slichter, Dean of the Graduate School of the University of Wisconsin, delivered an inspiring lecture entitled "Mathematics and Reality." This address will be found in the March number of the Journal.

The Friday morning session was concluded by an address by Dr. Francis D. Curtis, Professor of Secondary Education and of the Teaching of Science, University of Michigan, who spoke on the subject "Some Effects of the Depression Upon the Teaching of Science." His address will be found in a later number of the Journal.

FRIDAY AFTERNOON

Sectional Meetings

Following luncheon the members went to the seven different lecture rooms where the Sectional Meetings were held. The report of the secretary of each of these seven sections follows:

BIOLOGY SECTION

The meeting was called to order by the Chairman, Mr. J. W. Hadley at 1:45 P.M. with 24 members and nine visitors present.

The nominating committee consisting of Messrs. Smith, Lee, and Johnson presented the following names for officers of the section for the ensuing year:

Chairman: O. D. Frank, University of Chicago High School, Chicago, Ill.

Vice Chairman: Raymond Raymoth, Hyde Park High School, Chicago.

Secretary: Mary Allison Bennett, State Teachers College, Macomb, Ill.

The nominees were declared elected and their names were certified to the general association as officers of the Biology Section for the ensuing year.

Proceeding with the program Mr. Hadley, the chairman, introduced Dr. P. W. Holiday of the Shortridge High School, Indianapolis, Indiana who spoke on Classroom "Tests in Biology." A copy of his address is published in this issue of School Science and Mathematics.

Following this address, Mr. O. D. Frank of the University High School at the University of Chicago spoke on "Tricks of the Trade." Mr. Frank spoke in a very intimate informal manner that delighted his audience. He advised the science teacher to keep the pupils interested by keeping them busy. He suggested that the instincts and inclinations of the pupils be

utilized by the teacher of biology to the fullest extent possible. As examples of such inclinations and instincts which could be taken advantage of he mentioned curiosity, eating, collecting and "going places." He closed his talk with a description of the means which he employed in his own classes to secure spontaneous self expression in his own University High School classes.

Discussion was dispensed with, and the meeting was adjourned at 4:15 P.M.

FRED R. PLATT, *Secretary*

CHEMISTRY SECTION

In the absence of Chairman Clyde W. Holt of the East Technical High School, Cleveland, the Vice Chairman R. E. Davis of Lane Technical High School of Chicago, called the meeting to order.

Mr. Davis appointed the Nominating Committee as follows:

Mr. F. R. Bemisderfer, Chairman, East Technical High School, Cleveland.

Mr. A. F. McLeod, Sullivan High School, Chicago.

Mr. Lewis L. Hall, Morgan Park High School, Chicago.

Following the appointment of the Nominating Committee the following papers were presented to the Section.

1. "The Chemical and the Baking Industry" read by Victor Marx, Technical Editor, *Baker's Helper* Chicago. Paper was discussed by various instructors from the view point of baking as a vocation and the value of the chemical knowledge gained in High School to the vocation.

2. "High School Industrial Chemistry" read by E. G. Pierce, East Technical High School, Cleveland. Mr. Pierce showed several interesting projects made by pupils in classes taking this course. During the discussion which followed, Mr. Pierce introduced a former pupil who was present at the meeting. This gentleman testified as to the character of the courses offered in this type of chemistry and the benefits gained.

3. "The Chemistry Teacher and the Reduced Budget" read by Dr. B. S. Hopkins of the University of Illinois. In the discussion which followed hinged upon the fact of curtailing laboratory work in teaching chemistry in high school. Single period of Laboratory Work vs. Double Period. Various views were presented by instructors working under various conditions using modified methods, some under pressure of necessity. All the discussion led to a motion made by A. F. McLeod asking that the Chairman appoint a committee "for the study of the individual Laboratory situation in so far as the double period is concerned and that the Section go on record in favor of the individual laboratory work." Mr. McLeod suggested that it be called a "survey committee." Motion seconded: Carried.

Chairman R. E. Davis appointed on this committee the following:

Chairman: Dr. A. F. McLeod, Sullivan High School, Chicago. Dr. B. S. Hopkins, University of Illinois, Urbana. R. E. Whitney, John Marshall High School, Chicago. Dr. John C. Hessler, Knox College, Galesburg, Ill. M. J. W. Phillips, West Allis High School, West Allis, Wisconsin.

The Nominating Committee reported as follows:

Chairman: R. E. Davis, Lane Technical High School, Chicago.

Vice-Chairman: M. J. W. Phillips, High School, West Allis, Wisconsin.

Secretary: A. R. Stacy, Washington High School, Indianapolis, Ind.

The Report was adopted as read by F. R. Bemisderfer, Chairman of the Nominating Committee.

M. J. W. PHILLIPS, *Secretary*

ELEMENTARY SCIENCE SECTION

The second annual meeting of the Elementary Science Section was held on December 1, 1933, at 1:30 o'clock in the Gray Room, Congress Hotel, Chicago, Illinois.

The meeting was called to order by Mr. Ellis C. Persing, chairman. The minutes of the last annual meeting were read by the secretary and approved. A communication was read saying that the Board of Directors of the Central Association of Science and Mathematics Teachers at the meeting held on Nov. 26, 1932, formally made the Elementary Science Section a permanent one.

An interesting and instructive program was given as follows:

"The Teacher's Approach to the Problems in Teaching of Elementary Science." Ira C. Davis, University High School, Madison, Wisconsin.

"In Which Grade Should the Solar System and Its Relation to the Universe Be Taught?" Theodosia Hadley, Western State Teachers College, Kalamazoo, Michigan.

"Camping, an Important Part of a Child's Education in Elementary Science." *Illustrated.* Dr. William G. Vinal, School of Education, Western Reserve University, Cleveland, Ohio.

A general discussion followed the program.

The nominating committee consisting of Miss Helen Dolman, chairman, State Teachers College, Ypsilanti, Michigan, Miss LaVerne Argabright, Western State Teachers College, Kalamazoo, Michigan, and Mr. Ira Davis University High School, Madison, Wisconsin, presented recommendations for officers for the next year as follows:

Bertha M. Parker, Chairman, School of Education, The University of Chicago, Chicago, Illinois.

Florence G. Billig, Vice-Chairman, College of Education, Colleges of the City of Detroit, Detroit, Michigan.

Lillian Hethershaw, Secretary, Drake University, Des Moines, Iowa. It was moved, seconded, and unanimously voted that the report of the nominating committee be accepted.

An attendance of between fifty-five and sixty persons helped make the meeting a successful one.

FLORENCE G. BILLIG, *Secretary*

GENERAL SCIENCE SECTION

The General Science meeting of the thirty-third annual convention of the Central Association of Science and Mathematics Teachers was held in Room 1120 of the Congress Hotel at Chicago. The meeting was called to order by the Chairman, Paul G. Edwards, Supervisor of Science, Chicago, Illinois. He appointed the following nominating committee: Dr. Earl E. Sherff, Chairman, Head of Science Department, Chicago Normal College; Vernon W. Kelly, York Community High School, Elmhurst, Illinois; and Grace E. Peebles, Hyde Park High School, Chicago.

An interesting program was presented as follows:

1. "How much Should the Science Teacher Tell?" by O. D. Frank, School of Education, University of Chicago.
2. "Techniques for Pupil Participation," by James E. McDade, Ass't. Superintendent of Schools, Chicago, Illinois.
3. "What General Science Can Do for The Junior High School Student." by Joseph F. Gonnelly, Principal Hyde Park High School, Chicago, Illinois.
4. "A Teaching Unit—The Hygiene of the Human Body." by Walter F. Briney, M.D.; Graduate Student, Chicago Normal College.

Interesting and valuable discussion followed the above reports.

Dr. Earl E. Sherff, Chairman of the nominating committee, reported the following sectional officers for the year, 1934, and they were elected:

Chairman, Nathan A. Neal, East Technical High School, Cleveland, Ohio.

Vice-Chairman, Leonard Johnson, Roosevelt Jr. High School, Milwaukee, Wisconsin.

Secretary, Alma Thomas, Audubon Jr. High School, Cleveland, Ohio.

LEONARD JOHNSON, *Secretary*

GEOGRAPHY SECTION

The Geography Section met in Room 1102 of the Congress Hotel December 1, 1933. The meeting was called to order by the chairman, Edna E. Eisen, of the Steuben Junior High School, Milwaukee, Wisconsin, who presided.

In the absence of the secretary, Leonard R. Schneider, of the John Hay High School, Cleveland, Ohio, the chairman appointed the vice-chairman, Viva Dutton Martin, of the Arsenal Technical High School, Indianapolis, Indiana, to act as secretary.

A nominating committee consisting of Thos. H. Finlay, Chicago, W. O. Beckman, Elgin, and Miss Helen A. Southgate, Michigan City was appointed which later reported back with the following nominations for officers for the ensuing year: Chairman: Viva Dutton Martin, Arsenal Tech. H.S., Indianapolis, Ind. Vice-Chairman: Helen Turner, Oak Park-River Forest Tp. H.S., Oak Park, Ill. Secretary: Clinton Rich, 2534 Farwell Ave., Milwaukee, Wisconsin. The persons so nominated were duly elected.

The following program was presented, all of which is expected to appear in an early number of the Journal:

"Organization of Materials for Teaching High School Geography" by Alice Foster, formerly of University of Chicago High School.

"A Tentative Course in Political Geography" by Katharine Calloway, Calumet High School, Chicago, Illinois.

"Nationalism and Regional Planning: Their Relation to Secondary Geography" by Professor J. Russel Whitaker, University of Wisconsin.

"Individual Field Work in a Rural Community" by Clinton Rich, Milwaukee, Wisconsin.

VIVA DUTTON MARTIN, *Acting Secretary*

MATHEMATICS SECTION

The Mathematics Section met in the Gold Room of the Congress Hotel December 1, 1933, at 1:30 P.M. The meeting was called to order by the Chairman, Maurice L. Hartung, of the University High School, Madison, Wisconsin, who presided.

A nominating committee was appointed which later reported back with the following nominations for officers for the ensuing year: Chairman: DeWitt T. Petty, Francis W. Parker School, Chicago, Illinois. Vice-Chairman: J. Russell McDonald, Morton High School, Cicero, Ill. Secretary: Bess T. Baer, 594 West Main Street, Wabash, Indiana. The persons so nominated were duly elected.

The following program was presented, all of which is expected to appear in an early number of the Journal:

"Achievement Testing in Secondary Mathematics" by H. T. Lundholm, The Blake School, Minneapolis, Minnesota.

"Dimensionality" by Professor E. P. Lane, University of Chicago.

"Geometry's Tribute to Tradition" by Dr. Elizabeth B. Cowley, Pittsburgh, Pa.

PHYSICS SECTION

The meeting of the Physics Section was held in The Florentine Room, at 1:30 P.M. Dec. 1, 1933, the Chairman Mr. Elmer E. Burns, presiding.

The first speaker on the program was Professor Arthur L. Foley, head of the department of physics of the University of Indiana. Professor Foley discussed "The Goal of a Physics Teacher." This paper will be published in full in SCHOOL SCIENCE AND MATHEMATICS. Mr. Arthur Uhlir of Lane Technical High School, Chicago, gave a demonstration of the effects of inductance and capacity in alternating current circuits leading up to resonance and showed how such a demonstration could be made the starting point for a study of radio circuits. Mr. Uhlir made the point that it is a mistake to base the physics course on some one application and cited the fact that in the past few years the interest of pupils had shifted from the automobile to radio and to aviation. Dr. M. N. States, Director of Research of the Central Scientific Company, described the methods of producing the high vacua of x-ray and radio tubes and gave a demonstration with a tube which had been evacuated seven months previously and in which a seal of para rubber had held the vacuum.

The following officers were elected for the coming year. Chairman, John H. McClellan, Harrison High School, Chicago. Vice Chairman, Raymond Hornaday, Arsenal Technical High School, Indianapolis. Secretary, Walter E. Peterson Kelvin Park High School, Chicago.

F. M. CARL, *Secretary*

THE ANNUAL BANQUET

At six-thirty Friday evening the Thirty-Third Annual Banquet was held in the Gold Room, the President, Dr. Charles A Stone, acting as toastmaster. The diners were entertained by a splendid program by the Lane Technical High School Orchestra of ninety pieces under the direction of Mr. Oscar W. Anderson. Later Mr. Gordon R. Hanneman, accompanied by Helen Cecelia Hanneman, of the Music Department of the Central Y.M.C.A. College, of Chicago, presented a violin solo.

The address of the evening was given by Dr. Charles Hubbard Judd, Chairman of the Department of Education, University of Chicago, who spoke on "Scientific Thinking Contrasted With Memorizing Scientific Facts."

An additional feature of the evening was a series of demonstration lectures by sound motion pictures on topics commonly considered in physical sciences presented by Professor H. I. Schlesinger of the Chemistry Department of the University of Chicago. The object was to show how such demonstrations could be used to supplement ordinary classroom work and to permit more rapid presentation of material.

THE ANNUAL BUSINESS MEETING

The Annual Business Meeting was called to order by Dr. Charles A. Stone, President, at 8:30 A.M. Saturday morning, December 2, 1933, in Room 1164. The Treasurer, Mr. Martin, made his report, which was accepted, and several items of business relating to finances were disposed of. Dr. A. W. Hurd gave the report of the Research Committee of which he is chairman. Action on this was delayed until it had been further considered.

Mr. Fred Shriever gave his report as Chairman of the Conservation

Committee. This was accepted and is published elsewhere in this number of the Journal, Mr. Turton moved, and it was seconded and carried, that the Conservation Committee be continued.

Mr. Bemisderfer moved, and it was seconded and carried, that the proposed Amendment XII to Article 4, Section 2 of the By-Laws as previously printed in the Journal and in the Year Book be approved. This provides that the retiring president each year become a member of the Board of Directors for the following year.

Mr. James H. Smith gave the report of the Necrology Committee as printed elsewhere in this number of the Journal. It was moved by Dr. Schreiber, and seconded and carried, that this report be accepted.

Mr. Harvey Milford, of Detroit, Michigan gave the report of the Committee on Resolutions and upon motion by Miss Ulrich which was seconded and carried, this report was accepted.

Mr. Isenbarger gave the report of the Nominating Committee consisting of himself as Chairman, N. A. Neal, Marie Sangernebo Wilcox, W. R. Teeters, and Glen W. Warner, and moved that the Secretary cast the white ballot for these officers. The motion was seconded and carried. The officers so elected were:

President: Katharine Ulrich (G), Oak Park-River Forest Tp. H.S., Oak Park, Ill.

Vice-Pres.: Joel W. Hadley, (B), Shortridge High School, Indianapolis, Ind.

Board of Directors

For One Year to Fill Vacancy Caused by Resignation of Miss Ulrich:

Ernest O. Bower, (P), East Technical High School, Cleveland, Ohio.

For Three Years:

Harvey Milford, (B), Denby High School, Detroit, Michigan.
Clyde W. Holt, (C), East Technical High School, Cleveland, Ohio.
W. R. Teeters, (C), Board of Education, St. Louis, Missouri.
Walter W. Hart, (M), University of Wisconsin, Madison, Wisconsin.

Following the election, the President-Elect, Miss Ulrich, spoke briefly, after which the members adjourned for the Saturday morning program of Lectures.

THE SATURDAY MORNING GENERAL PROGRAM

The Saturday morning general session was opened at nine o'clock in the Gold Room by an excellent program by the A Capella Choir of the Roosevelt High School, of Chicago, under the direction of Erhardt Bergstrasser.

Following the musical program Dr. Stone introduced Mr. Charles H. Lake, Superintendent of Schools of Cleveland, Ohio, who spoke on the subject "Looking Ahead in Science Teaching." His address may be found in this number of this Journal.

Then, Dr. Ernst R. Breslich, Associate Professor of the Teaching of Mathematics, University of Chicago, spoke on "Coordinating the Activities of the Departments of Science and Mathematics in Secondary Schools." This address may be found in this number of this Journal.

The lecture of Dr. Arthur H. Compton, Professor of Physics, University of Chicago, on the subject of "Cosmic Rays" is reported as follows by Mr. Walter E. Peterson:

DR. COMPTON—COSMIC RAYS

Dr. Arthur H. Compton, Professor of Physics, University of Chicago, gave an illustrated lecture on Cosmic Ray investigations. He outlined the three extant theories concerning the nature of cosmic rays. Cosmic ray investigations are primarily concerned with checking these theories. Illustrations were shown of the portable ionization chamber designed and used by Dr. Compton. It is thought that terrestrial magnetism deviates the rays as they approach the earth. Hence, it is important to learn the direction and intensity at various latitudes and altitudes. The results of numerous expeditions were discussed. He told of his own expedition to the Andes where numerous determinations were made at high and low altitudes near the equator. He made a journey to the northern end of Greenland on an ice patrol boat and obtained results of great significance. It seems that in this field of physical research the scientist is released from his stuffy laboratory and must acquire skill as an alpinist, a horseman, and a sailor in addition to proficiency in mathematics and mechanical designing. Dr. Compton seems to have acquired these skills as well as those of an interesting lecturer and teacher.

Following the Saturday morning program a luncheon was given at the hotel in honor of the newly elected officers, after which the newly elected general officers and sectional officers and the Members of the Board of Directors met for a business meeting while members who desired to do so went on a visit to the Physics Museum of The University of Chicago under the leadership of Mr. C. E. Holly, of the University of Chicago High School.

THE SATURDAY AFTERNOON BUSINESS MEETING

The meeting was called to order by the new president, Miss Katharine Ulrich.

Mr. F. R. Bemisderfer of Cleveland, as chairman of the Committee on Place of Meeting, the other members of the committee being Mr. Walter G. Gingery, of Indianapolis, and Mr. Ira C. Davis, of Madison, Wis., recommended that Indianapolis, Ind., be the place of meeting next year.

Mr. Isenbarger moved and it was seconded and carried that the convention go to Indianapolis next year.

Professor Walter W. Hart gave the report of the Journal Committee of which he is chairman, telling of the favorable financial condition of the Journal. Dr. Stone moved, and it was seconded and carried, that this report be accepted.

Mr. G. T. Franklin spoke on the condition of the Association from the standpoint of members as he gave the report of the Membership Committee of which he is chairman. Several spoke commending the excellent work of Mr. Franklin and his committee.

There was much commendation of the manner in which Dr. Stone handled the convention and the publicity connected with it.

Dr. Stone moved, and it was seconded and carried that Dr. Hurd's Report of the Research Committee be accepted.

Mr. Isenbarger moved, and it was seconded and carried, that Dr. Hurd's Research Committee be continued for another year.

Mr. McDonald nominated Mr. Gingery and Mr. Ira Davis for members of the Executive Committee. This nomination was seconded and the two members elected.

Mr. Roecker presented the report of the audit of the Treasurer's books. Mr. Carnahan moved, and it was seconded and carried that this report be accepted.

Dr. Stone moved, and it was seconded and carried, that Ross B. Wynne continue as Secretary of the Association for another year.

Motion to adjourn was made by Dr. Stone and it was seconded and carried.

Respectfully submitted

ROSS B. WYNNE
Secretary of the Association

REPORT OF THE NECROLOGY COMMITTEE

To the Central Association of Science and Mathematics Teachers: your committee knows of the death of only two members during the year, namely: Charles A. Marple, head of science department of Central High School, Cleveland, Ohio; joined the Association about 1902; at one time Chairman of the Physics Section; was very active and successful in making and executing plans for the entertainment of the Association at its meeting at Cleveland in 1932. Died in June 1933. Mr. F. R. Bemisderfer reports as follows:

"It is with deepest regret and with a full consciousness of a very great loss to this Association, to Ohio, and to the nation, that the Central Association of Science and Mathematics Teachers reports the death of Mr. Charles A. Marple in June, 1933.

"Mr. Marple was one of the few who spent an entire life teaching and continued to grow throughout his entire teaching career. This Educator as Head of the Science Department of Central High School, Cleveland, Ohio, held a large reservoir of energy, remained in good health, largely because of his ever evenly tempered disposition, and scintillated with sparkling Science and Mathematics gems through his seventieth year, at which time he was compelled to retire in June of 1932. He was also President of the Cleveland Teachers Federation from 1924 to 1927.

"Mr. Marple joined the Central Association of Science and Mathematics Teachers about 1902, and with Franklin T. Jones, organized the Northeastern Ohio Division of the Association. At the time of his retirement, he had been honored by this Association as Chairman of the Physics Division. During the Fall of 1932, he was the largest single contributor to the success of the Cleveland Convention of Science and Mathematics Teachers, Inc.

"May this Association forever remember its Pillar."

Gordon F. O'Connor, head of the science department of Fond du Lac, Wis., Senior High School; joined the Association in 1928; took a marked interest in the programs of the Association and in its official journal, SCHOOL SCIENCE AND MATHEMATICS; died Oct. 17, 1933. The *Wisconsin Journal of Education* says:

"Gordon F. O'Connor 43, head of the science department at the Fond du Lac Senior High School, Wis. and veteran of the World War died by his own hand, at Fond du Lac, October 17. Mr. O'Connor had been suffering from a serious nervous disorder for many years, and friends attributed that to his death. He had taught in Fond du Lac for the past 13 years."

Respectfully submitted,

JAMES H. SMITH, *Chairman*
CLARENCE E. COMSTOCK
CHARLES M. TURTON

REPORT OF THE CONSERVATION COMMITTEE

This Committee, appointed November 29, 1930, has twice reported its findings, and has been continued for further study of the question of Conservation Education in the Secondary School curriculum.

After these several years of study and observation, the Committee reports as follows:

1. Need for thorough-going instruction in the subject of Conservation of Natural Resources is apparent and urgent. Unless we make an immediate and sufficient effort to overcome deficiencies in this regard, and succeed in establishing, presently, a conservation conscious generation of young men and women, our nation will suffer accordingly.

2. We recommend continuous committee study of this problem, for its solution has scarcely begun.

3. We recommend that Conservation Education be included as an aspect of other subjects of instruction, until such a time as other, better methods of instruction be determined and adopted.

4. Our investigation shows that teachers, here and there, have made correlations between science and English, between science and social science, and between manual arts and English for example, for the purpose of fostering effective conservation attitudes. Teachers also report increased benefits to such regular studies where correlation has been attempted.

5. We find that even among teachers of Science and preponderantly so in other subjects of the curriculum, teachers fall far short of the needs of the hour in presenting subject matter from the conservation viewpoint.

6. Teachers' conventions should stress the necessity of conservation education.

7. Teachers must be sold the Conservation idea; they must also be trained and assisted in teaching it.

(a) Textbook reviewers and publishers should emphasize conservation topics wherever feasible in academic subjects.

(b) Lists of available bulletins, texts, agencies, and other means suitable for instructional uses should be made available to all teachers.

(c) Courses in teacher training schools and in colleges must be provided for wider teacher preparation for teaching conservation.

(d) This association should assume leadership among the several educational associations best fitted for this work. Through its committees a substantial contribution can be made. For instance, definite overtures may be made to the biology teachers or the social science teachers or to the National Council of Teachers of English, in regard to correlating conservation education.

(e) Complete courses and supplementary outlines for teaching conservation in general science, biology, English, social science subjects and manual arts should be made available to teachers in general.

Respectfully submitted,

P. H. Houdek, Robinson, Illinois
O. D. Frank, School of Education, University of Chicago, Chicago, Illinois
J. L. Cooprider, Central High School, Evansville, Indiana
R. B. E. Simon, Western Reserve Academy, Hudson, Ohio
Fred Schreiver, Chairman, Boys' Technical High School, Milwaukee, Wisconsin.

LOOKING AHEAD IN SCIENCE TEACHING*

By Charles H. Lake
Superintendent of Schools, Cleveland, Ohio

Education is particularly concerned with human relationships. There can be no other purpose of education. It is people only that count in this world of ours. Our plan of government must succeed or fail through our system of education. It is based upon the idea than an informed and intelligent citizenry will make it possible for a government by the people to continue with ever increasing success.

In the past few years our economic situation has given us cause to stop and check on the gross weaknesses of our financial system, the inadequacies of our social plan, and the follies that have crept into our political system. These are the results of prosperity, not depression. The depression has only unveiled them for our eyes which have been too busy looking for profits to see the pitfalls.

Just now we are advocating a kinetic philosophy of education, which is applicable to a rapidly changing society. All educators are discussing it but there will be considerable resistance to much change. Habits of individuals are very persistent and they will keep people doing for generations the things to which their forefathers were habituated and accustomed. Like horses we run back into the fire at the first opportunity. I suppose there is a serious doubt as to whether a person who can not think without training can ever be trained to think. Still we shall have to agree that the person who has the ability to think can do a much better job of it if he is informed and is given the opportunity to practice on materials that may be of most worth to society.

Most of our progress has come as the result of crises. Under conditions which develop during a catastrophe such as a flood, an earthquake, a tornado, a war, or a financial panic, some people will think about the problems at hand, to some purpose. If the danger is a common one to a large number of people, there will be cooperative thinking and planning for the common good. When the danger applies only to your neighbor it rarely seems as ominous as when it also applies to you. When the banks fail in Detroit, it doesn't seem such a national catastrophe

* Read before the General Session of the Annual Meeting of the Central Association of Science and Mathematics Teachers, Dec. 2, 1933.

as when they fail in Chicago, if we happen to live in Chicago. We have finally reached a crisis in education and in other governmental services. The problems arising from the situation cannot be solved expeditiously in the field of education alone. It will take time and while they are being solved there will be financial troubles, inadequate schools, hunger, educational patching here and there, but out of it will come better systems of taxation, better plans for the financing of education and for financing those other governmental services which alone make government worth while. How much may we accelerate the process?

Society accepts scientific progress. The coach and four, the pony express, and the sailing ship have gone and in their place we have the automobile, the airplane and many means of very rapid communication. However, we still adhere to many economic and social traditions which belong with those antiquated methods of travel and communication.

Our economic and social problems have much increased educational needs, which we have but very partially met. Most changes in curricula come through a sort of evolutionary process but they do come as any one must acknowledge who compares our present curricula with those of some years ago. Science has had much to do with this change. I have been reading Anthony Adverse. Well, you may or may not like the book but you are rather vividly impressed with the differences in the methods of doing business, of travel, and of communication some 140 years ago and now. Technical progress has put new premiums on technical knowledge but if we are to succeed to the extent that we must, we must apply more technical methods to the solution of problems in the field of government, economics and sociology.

In some respects the teacher of science has a distinct advantage over the teacher of other subjects in the secondary school field. His teaching has been rather definite and he has not been so harassed with questions of what should and should not be taught. Just now I am wondering whether the teacher of science has at all times realized the advantage of his position in the possibility of training his students to approach social problems with the same open mind that he brings to scientific problems. To what extent do we believe the things we have been taught to say? We say that the only hope for a democracy such as ours must lie in our system of education. Yet we have no ade-

quate plan for financing education, no plan which frees education from the political, social, and economic vagaries of thousands of small independent taxing districts.

Education, of course, can not be much better than the forces in control and since these forces vary so widely with different communities, small and large, of course educational offerings and opportunities must vary widely. These forces are the forces that you know so well. Some of them are political, some social, some financial, and any or all of them may be violently emotional. Education is not yet free from propaganda. What can we do? What are the problems of contemporary civilization? What can the schools do to develop a desire for a better civilization, one in which people may not starve and go without adequate clothing and shelter in the midst of plenty, or in which such a vast proportion of our people eke out the most meager existence? Well, the first step in getting the answer to this question is—adequate and certain financial support for our schools. We are just now in the midst of a program of spending $400,000,000 in ten weeks for civil works projects. Of course, it is a worthy relief measure. But education needs relief also if it is to be free to do the work that we expect of it. A plan of adequate state support can be developed and accomplished through legislation in a short period of time and we must not falter until it is accomplished.

In the latter part of the last century Pasteur said, "In our century science is the soul of the prosperity of nations and the living source of all progress. What really leads us forward is a few scientific discoveries and their application."

And now here we are, a third of the way through the twentieth century, harassed with all sorts of doubts concerning the answers to the many questions that arise for our deliberations. Science has made very rapid progress in the thirty-three years of this century. In every important field of science there have been recent discoveries that have exerted a profound influence upon human thought and action. Scientific discoveries with far reaching implications are taken as a matter of course. The public discusses them with varying degrees of understanding, while the scientist goes on in pursuit of other bits of elusive knowledge refusing to be much concerned with interpretations of his work for the world at large.

There is a story, more or less mythical I suppose, to the effect that when Henry George went to one of our great American

colleges to explain his economic theories to the economists there, he came away disheartened and said that the only men there who could understand his plan were the scientists. Whether their training gives the scientists any particular advantage in understanding principles in other fields of learning or not, they certainly have an obligation to apply the techniques they have acquired for the solution of problems in science to problems in the social field, just as they have an obligation to interpret their research in science to society so that the full significance of their discoveries may be realized by their unscientific neighbors.

Regardless of the field of endeavor in which we work, we must all accept the social obligation to understand what is going on in the world and take a part in the direction of our government and social planning, if it be only to vote on the basis of facts. Facts, of course, are valueless unless they are given direction and meaning through associations which can come only through interpretations, and the wisdom of all of us is needed to refine these interpretations so that they may become the irrefutable basis of working plans for a society such as ours.

The scientific mind of today is a marvelous instrument of productivity. It works to satisfy itself as to what the universe is, as to what is beyond the farthermost star, as to what the composition of matter may be, as to what the nature of cosmic rays may be; it discovers countless ways of extending life and of making life more enjoyable; it explores the polar regions, the depths of the sea and the mysteries of the stratosphere; but it falters before the social and economic problems of our contemporary life. In these fields the scientific mind is quite similar to other minds in so far as we have evidence of achievement. It seems not too much to hope that the scientific method may be extended, that we may find ways to develop in the minds of young people an attitude of mind which will keep them free from the biases due to emotions and prejudices. You will probably say that it can not be done. However, there is no other way; we must continue to try through a refinement of our methods and materials in education.

Our scientist must believe in a much higher evolution for man than that which we have now attained. It is a reasonable belief. Our progress scientifically has been better than we have predicted. The progress now must be in the development of a better understanding of human relationships. We have to be-

lieve that we have enough mental power to learn the rules of the cooperative game that we must play if we are to exist.

Then what is there to do? We can work to develop a demand that the scientific spirit be extended to all worth-while effort for which the community has a use. We can insist that all teachers and prospective government workers bring to their work an adequate fact content of knowledge, an ability to interpret this knowledge accurately, and courage to use it effectively. There is no easy way to scientific achievement or to achievement in any other field. Majority votes should be convincing, but they cannot be so considered until the magic is taken out of propaganda by scientific methods applied to the whole field of social relationships.

The "ages" by which we have designated periods in the development of man have been mainly names of periods indicating man's scientific progress. The stone age, the age of bronze, the age of iron are examples of such designations. The geologic ages also represent more or less scientific divisions of past time. Recently we have been speaking of the age of electricity, the machine age, and the automobile age. We have had much written to the effect that our technical knowledge has been outdistancing our knowledge of social problems. Certainly the answer to this problem of maladjustment and inequality in our development does not lie in retarding scientific progress until social progress catches up with it but in accelerating social development so that it may catch up with science.

Here is a real challenge to the scientist. This age should be definitely the *social age of man*. There are literally hundreds of social problems which will yield to scientific treatment, in my opinion, and the scientist is the only one who possesses the technique for that treatment. Of course, I do not mean that there are no scientists working in the field of social problems. The number, however, needs to be extended greatly and it seems to me that the scientist and the science teacher possess the key to the situation. Suppose, for example, that we extend the field of science to include a study of the housing problem in our cities. Our cities, as you know, are not old cities. We know what the curves of growth have been for the original areas of cities and for the original areas *plus* each additional area accruing through annexation. We know that the social problem of housing in these areas becomes increasingly acute with the

age of the district. What is the practical scientific answer? Isn't it worthy of a doctor's thesis or the interest of the most ardent student of science?

This problem of housing will, of course, be intimately connected with the whole problem of city health and with all those services which in some form or other fit into a health program. It will include a scientific study and a subsequent interpretation of the whole field of recreation which we have been bungling for years. If we complain about our movie made minds, we should have something as attractive as the movies to substitute. Is there such a thing as a satisfactory substitute for certain individuals? The answer must certainly be yes. In fact, our investigations to date confirm the statement. But my purpose here is not to list those social problems which may yield readily to scientific investigations but simply to suggest that this is the field now which more than any other must be considered if our democracy is to succeed and to enter the plea that we plan to center the attention of our best minds upon it.

Man is very old on the earth. He has persisted because of his mental ability in spite of his physical handicaps. He has the power to analyze his place in the scheme of things in relation to all other life and to plan his future. Are we concerned with our future? Certainly, but the tendency is not to take it too seriously. Well, I am not advocating that, but our future will be much more interesting if we attack the problems of social relationships with an intensity equal to that which has prevailed in industry and in science. If social progress is lagging, then the next great advance must be in this field.

One of our greatest curses has been in opinions and conclusions not based upon facts. Generalizations in social science often are the result of little or no investigation. Some one has said, "One positive result in social science produces a generalization, while one negative result in science destroys a generalization."

Is man the master of the civilization he has created? Can he control the machinery he has produced? Can he keep abreast with his own scientific creations?

Our social plan to date has had in it a very great deal of individual selfishness. Man certainly must have enough mental power to develop a social plan worthy of himself, and secure for it enough thinking cooperation to obtain its acceptance, to the

end that we may have a clearer understanding of the meaning and purpose of our own lives and some conception and assurance of man's future.

In our schools we must have much science. Personally, I advocate it in all grades from the third through the twelfth. In grades seven to twelve, there should be some reorganization. We have compartmentalized it too thoroughly, and we have been too radical in our demands for rigid course units. In grades seven, eight and nine the course should be organized so that each pupil will have three periods a week; in grades ten, eleven and twelve the science courses probably will have to be elective. These courses should all be five periods a week. It is my belief that biology, chemistry and physics can be, and should be, organized so that the work may be done in five periods a week. This means, in most cases, simply a reorganization of the laboratory work. As you people so well know, there has been some research on this subject and for all pupils with intelligences of 90 or above the results show that the pupils who have five periods a week do just about as well as those who have six periods. I have supervised classes in physics that spent ten periods a week, eight periods a week, seven, six, and five; and while I realize that it is nice to have plenty of time, it seems to me that the position of the science teacher will be strengthened if the work is reorganized on a five period basis.

In the Cleveland senior high schools, we have conducted considerable research on subject costs. From 1928 to 1933 the class teaching periods per week per teacher increased from 26.34 in 1928 to 27.99 in 1933. This is an increase of 1.65 periods per week or 6.26%. Pupils per teaching period increased from 28.3 in 1928 to 34.7 in 1933, or an increase of 22.61%. Combining these increases, $1.0626 \times 1.2261 = 1.3029$, or an actual increase in teaching load of 30.29%. If teachers' salaries per teaching period had remained constant during the five years, the increase of 30.29% in teaching load would have resulted in a saving of 23.25% in the expenditure per unit of teaching service. The per pupil expenditures for teachers salaries—5 periods a week, 38 weeks—were:

For *all subjects*—in 1928, $15.02—in 1933, $10.41

In the sciences:

Biology, in 1928, $15.03—in 1933, $10.28
General Science, in 1928, $16.37—in 1933, $11.47

Chemistry, in 1928 $17.68—in 1933, $11.29
Physics, in 1928, $18.97—in 1933, $12.35
—somewhat above the average for all subjects for five periods and, of course, you must add 20% to these figures for each period above five that is given to the subject. In these days when we are evaluating, with such care, educational services, courses of study, and curricula, isn't it a good time to make the move of reducing the time in science from six or seven periods a week to five? Will not more pupils take the science courses under such cases, and will not the position of the science teacher be much strengthened?

The paramount problem that confronts the schools today is to reconstruct society into a thinking and critically constructive public, alert to the demands of the times and skeptical of the claims of the demagogue.

HEAVENS WOULD LOOK DIFFERENT IF WE COULD SEE INFRARED RAYS

Night skies would take on a decidedly different appearance if our eyes were sensitive to infrared radiations as they now are to visible light, C. W. Hetzler of Allegheny Observatory, Pittsburgh, declared in the course of an address before the meeting of the American Astronomical Society. The constellations would still be there, but individual stars would have apparent brightnesses vastly different from the ones with which we are familiar.

For some stars that are not particularly bright with visible light give off very large amounts of the invisible infrared radiations: they are "bright" with "dark" rays. This is especially true of certain of the long-period variables—stars whose visible light fluctuates in intensity through many months, or even several years. These stars give off tremendous radiations in the infrared. Unlike many of the stars that are intensely red in the visible spectrum, they are not dwarfs; quite on the contrary, they are giants.

These hot giants vary in their infrared radiations as they do in their rather dim visible light, but not to nearly so great an extent. The fluctuation of one of these stars in the invisible rays is only one-third or one-half as great as it is in the visible part of the spectrum.—*Science Service*

"PICTURESQUE WORD ORIGINS"

This is the title of an unusual story book based on facts from Webster's New International Dictionary. Many of the stories about words are illustrated. The book is unique, artistic, instructive. From it we learn that *neighbor* once meant a near-by farmer, a *broker* was a vender of wine, a *candidate* was one clothed in white, an *assassin* was a drinker of hashish. We agree that the old meaning for *taxicab*, "a carriage that bounces like a goat" is still good but do not usually think of *manufacture* as "making by hand." The book is published by G. and C. Merriam Company, Springfield, Mass.

COORDINATING THE ACTIVITIES OF THE DEPARTMENTS OF SCIENCE AND MATHEMATICS IN SECONDARY SCHOOLS*

By E. R. Breslich
The Department of Education,
The University of Chicago

Elimination of waste in teaching.—The highly departmentalized organization of the secondary school offers certain advantages. It stimulates improvement in teaching. It encourages and trains teachers to become thoroughly familiar with the subjects of their choice. Intensive interest in a special subject keeps them in touch with progressive developments and innovations, and often repeated experiences enable them to master the methods and procedures most effective in instruction in their respective fields. The advantages, however, may be greatly offset by certain serious disadvantages unless care is taken to avoid this. A teacher may become so absorbed in his special subject that he has little or no time, and often no interest, to keep informed about the work done in other departments. Thus it happens that the same subject matter is presented by several departments. Time is thereby lost which could be employed in a more profitable way. For example, in most schools the departments of mathematics and of the social sciences both offer instruction about investments, banking, insurance, taxation, and keeping accounts. Rarely does either department know how the work is being carried on by the other. It may be quite possible to divide it between them. The basic ideas belonging to these topics may be taught in the social science courses since it would probably be more skillfully taught by the teachers of the social sciences than by the teachers of mathematics. The intensive problem work related to them could then be done in the mathematics courses. Such an arrangement not only avoids duplication but it may at the same time bring about better results.

Careful analysis of the offerings of all departments discloses a considerable amount of unnecessary duplication. Thus the departments of science, mathematics, and art teach pupils how to measure with ruler, compasses and squared paper. In mathematics and art much work in designing and ornamentation is

* Read at the General Session of the Annual Convention of the Central Association of Science and Mathematics Teachers, Dec. 2, 1933.

duplicated. In mechanical drawing and geometry the same identical constructions are taught. The topics of latitude and longitude are treated in geography and mathematics.

The problem of eliminating wasteful duplication should be given serious attention. It should not be a difficult matter to determine which department is best qualified to assume responsibility for topics now taught in more than one.

Removal of artificial barriers.—Another unfortunate outcome of departmentalization is the tendency to keep learning restricted within narrow fields. As a result the pupil fails to apply in one what he has been taught in another. Often this is the cause of dissatisfaction, misunderstanding and even friction among departments. Indeed they may go as far as to accuse each other of doing poor teaching. The persistent complaint, voiced by teachers of the sciences and the manual arts, that the teachers of mathematics are not doing their work effectively is a well known example.

The tendency to set up artificial divisions has developed also within the subjects. Courses have been formed in which particular phases of a field are studied intensively to the exclusion of all others. Geometry is taught without any reference to algebra. Geography is separated from history. Each of the natural sciences is presented without bringing in related materials from the others.

Artificials divisions within subjects and among subjects have been regarded by many educators as an important factor contributing to the unsatisfactory results of education. Efforts have therefore been made for some time to provide broader training by the method of coordination. Within most fields so-called "general" courses have been established. Thus the science department has organized courses in "general science." In mathematics a variety of general courses has been produced. They are known as "unified," correlated," and "general" mathematics. The manual arts have introduced courses in "general shop." In response to the charge that the social sciences are failing to prepare pupils adequately for the complex problems which modern society must face, attempts are now being made to bring about improvement by uniting into a general course materials of instruction which formerly were distributed among such courses as history, geography, economic society, and modern problems.

Changes in time allotment.—There are other good reasons

for reorganizing the content of high school courses. The realization of the importance of making the school increasingly competent to help pupils acquire an understanding of modern social conditions and to prepare the present school population to solve the social problems of the future intelligently and successfully, is creating a demand for more emphasis than formerly on the social sciences. In many schools the time alloted to them has been or is being increased. If the movement should reach nationwide proportions it is evident that corresponding to each increase in the time alloted to one subject there must be a decrease in others. Every time reductions have to be made by a department it is facing the problem of making up the loss. This may be done by increasing the effectiveness of teaching, by dropping subject matter that has relatively little value, by postponing that which has only deferred value, and by eliminating needless duplication. In making these adjustments not only will the cooperation of the teachers within the departments be required, but a plan of coordination of the activities of all departments will have to be worked out, especially of those closely related to each other. Each department will have to re-examine the content of its courses to find ways of saving time and improving instruction so as not to interfere with the broad training of the pupils. The welfare of the pupils should be of first importance and departmental interests should be second to receive consideration.

Saving time by cooperation of all departments.—The problem of improving the results of instruction, regardless of the fact that the amount of time is being reduced, may be difficult to solve but the solution is not impossible. Indeed, it has been worked out in some schools in which teachers were willing to cooperate in the experiment.

The teaching of English in secondary schools illustrates the method. Responsibility for teaching the English language used to be placed entirely upon the department of English. All pupils were required to study the subject for the four years which constitute the high school period. This was considered ample time for the training in English language. Little attention was paid to this phase of high school education in subjects other than English. When deficiencies appeared the English department was criticized for its inability to train pupils successfully to express themselves in correct oral and written language. The method did not solve the problem and the deficiencies persisted

in spite of the best efforts made by the teachers of English.

A different method was employed by some schools which made training in English a cooperative undertaking of the entire teaching staff. The function of the English department was to offer well organized systematic training in language but every teacher in the school became a teacher of English. It was expected that teachers of all subjects would frequently waive aside departmental interests when it became necessary to supplement the work of the English department. Information about outstanding cases of bad English was passed on to that department. Gratifying results have been attained. An interesting fact is that the plan made it possible to reduce the number of English courses required for graduation and that, at the same time, it improved the quality of English of the pupils.

Cooperation in the training of pupils in arithmetic is another example which shows what may be accomplished if the entire faculty participates. High schools are criticized by business men and college teachers because many graduates are found who are poorly grounded in arithmetic. At first thought it might seem that the responsibility rests with the department of mathematics. Some schools have gone so far as to add to the mathematics curriculum a year's course in arithmetic for the freshmen. The results, however, have not been sufficient to justify the extra time, especially since the fundamental processes of arithmetic have all been taught before the pupil enters the seventh grade and since the subject is usually given much emphasis in grades seven and eight. Nevertheless, the high school should be able to graduate only pupils who are well grounded in arithmetic. In some schools this has been accomplished by making proficiency in arithmetic an educational objective of every department, including the department of mathematics. Each must contribute to the arithmetical training of the pupils. No teacher may evade the responsibility by avoiding situations which offer opportunity for training in arithmetic. The sciences and mathematics, of course, are in the most favorable position to contribute. Measured results have shown that a course in physics may add to the arithmetical growth of pupils as much as a course in logarithms and trigonometry.

The nature of science and mathematics is favorable to correlation.—The present tendency in education to improve the results of teaching by integrating high school subjects should be

of special interest to the teachers of science and mathematics. History shows that the union of the two fields has been an important influence in developing both. Investigations of problems in science have frequently led to discoveries of valuable facts and principles of mathematics. The two fields have so much in common that some have classified physics and chemistry as branches of mathematics.

One of the major aims of secondary education is to lay the basis for an understanding of modern conditions. Hence the natural sciences will deserve a prominent place on the curriculum of the secondary school as long as they really aid the pupil in understanding the laws and forces of nature and their functions in the activities of every-day life, and as long as they help him adjust himself to his environment. Since a knowledge of mathematics is essential in attaining a clear understanding of the laws and relationships which are to be mastered in the study of the sciences, close correlation of science and mathematics should be of great value to the sciences. A large amount of the content of mathematics, as, for example, a knowledge of formulas and graphs, is needed as much in science as in mathematics. Indeed, advanced study and research in the sciences can not be carried on successfully without a thorough knowledge and understanding of mathematics. On the other hand, the sciences are in the position to provide materials and techniques of methods of investigation which are useful in the study of mathematics. The problems and formulas of science offer a genuine incentive for practice in computation and problem solving.

The idea of correlating science and mathematics in the secondary school is not new. At the beginning of the present century the movement gained considerable momentum. Leaders in both fields discussed it widely and endorsed it unhesitatingly. Some very important results have been attained. One direct outcome was the formation of the *Central Association of Science and Mathematics Teachers*. It has done a splendid piece of work for the advancement of both subjects. SCHOOL SCIENCE AND MATHEMATICS holds an uninterrupted record of reports of investigations and contributions of great value to the teaching of science and mathematics. References to articles that have appeared in the volumes of that magazine are found in all educational publications in which the problems of teaching science and mathematics receive attention. In the early issues of the journal appeared a number of articles describing successful

attempts of bringing the two departments closely together. Many teachers of mathematics were stimulated to introduce the laboratory method and other methods characteristic of science teaching. The use of such methods made it possible to derive experimentally many interesting facts of mathematics formerly withheld from the pupils until they could be demonstrated by logical proof. This paved the way for the development of intuitive types of algebra and geometry which are now generally taught during the junior high school period. Moreover, in some schools many experiments which traditionally were performed in science courses were transferred to the mathematics department. For example, the laws of the parallelogram of forces, of leverages, of the inclined plane, of the composition and resolution of forces, of reflection and refraction of light, were worked out in the mathematical laboratories.

It is unfortunate that the correlation of science and mathematics which had such a promising beginning did not continue to make the progress expected by those who advocated the plan. Indeed, the ground made has been almost lost. The main obstacles were the lack of laboratory equipment of the departments of mathematics, the scarcity of teachers qualified to teach both mathematics and science and the tendency of specialists to concentrate on one subject to the exclusion of all others.

Mathematical deficiencies of pupils taking science courses.—The old complaints of teachers of science about poor teaching of mathematics and about the pupils' inability to use the mathematics needed in the study of science have persisted, if not increased. Some say that the lack of mathematical knowledge is a disturbing factor in science and that it adds greatly to the difficulty of the subject.

On the other hand the teachers of mathematics complain that they do not dare to introduce applications from the field of science because the pupils do not know the meaning of the basic concepts and laws of science. As long as each group does no more than to place the blame on the bad teaching of the other, the situation will remain unchanged.

Attempts to improve the mathematics of science pupils.—Some science teachers have tried to solve the problem by determining the specific difficulties, facts, skills, and processes of mathematics which are needed in the various science courses. Tests have been designed to determine the mathematical deficiencies

of the pupils. The results of the tests have been used in two ways. One is to bar the pupils from the course until they can show that the deficiencies have been removed. The other is to admit them to the course and to have the deficiencies made up gradually during the progress of the course. Several studies aiming to determine the mathematics needed in physics and chemistry have been reported in the recent issues of SCHOOL SCIENCE AND MATHEMATICS and of the *Mathematics Teacher*.

A very effective attack on the problem may be made by analyzing carefully all the complaints of the teachers of science. Some of them are found in published articles and others may be obtained directly from the teachers in the science department. In a general way these complaints may be grouped into four classes: (1) Pupils do not have a clear conception of the basic mathematical concepts and processes; (2) they are unable to express in precise mathematical symbolic language the rules, principles, and quantitative relationships encountered in science; (3) they do not understand formulas sufficiently to use them as a means of simplifying the thinking about these relationships; (4) they are too easily distracted when unfamiliar situations enter into problems.

The foregoing general classification is interesting but of comparatively little value in planning a remedial program. What is needed is a detailed list of the specific mathematical deficiencies and difficulties which actually arise. If a record of such difficulties is kept by the science teachers and if their findings are made available to the mathematics teachers this will go far toward the solution of the problem. It is evident that the plan requires the closest cooperation of the science and mathematics departments. An understanding must be reached as to the most effective remedial steps. The best results will be obtained only if each department agrees to assume definite responsibilities.

Obligations of science teachers toward mathematics.—It is not always the fault of the mathematics teachers if pupils are unable to use their knowledge of mathematics in the study of science. For example, a pupil in a science course may be unable to find the value of $10^{4.6}$, not because he does not understand the meaning of exponents but because he had but few experiences in mathematics with problems in which the exponents were decimal fractions. So far he has acquired only a partial understanding of exponents. The natural place for offering experiences with powers whose exponents are decimal fractions

is in the sciences where they occur rather than in mathematics. An agreement may therefore be reached that the task of extending the notion of exponent to include decimal fractions is to be assumed by the teacher of science. However, should the pupil in his study of science have difficulty with 10^{-3} the responsibility for eliminating the deficiency should rest with the mathematics department which can and should provide ample experiences with problems containing powers with negative exponents. It requires the combined effort of both departments to bring about a real understanding of the exponential notation.

The mathematics department has been criticized because pupils fail to acquire a technique of solving verbal problems. It is found that they have great difficulty with the verbal problems which they have to solve in science courses. This is another case which can not be disposed of by the mathematics department alone. It requires the cooperation of all departments, especially the science department. Problem solving is a complex process. It involves a number of difficulties any one of which may prove fatal. Much has been said in the educational literature to offer helpful suggestions to teachers who try to develop skill in problem solving. Development is slow and variety of experiences is essential. Training usually begins in the elementary school and continues during the high school period in all mathematics courses, but the results do not correspond to the amount of time and effort expended. Much may be accomplished, however, with the cooperation of the science teachers if they can be induced to share in the responsibility of training pupils in the technique of problem solving.

The fact that science and mathematics teachers employ different methods is sometimes the cause of misunderstanding. It is natural that the mathematician whose interest is in the teaching of algebra and in developing skill in the use of algebraic processes slights the arithmetical methods. He may go as far as to forbid pupils to use them. The science teacher, however, may be partial to arithmetical methods and insist that they use them in preference to algebra. Thus in one course the pupil is instructed to solve his problems by arithmetic. In the next he is told that an arithmetical solution will not be accepted. It is no wonder that he is confused. It may affect seriously the quality of his work. Situations of this type need to be eliminated by agreement between the two departments. It is quite possible that one group might be converted to the point of view of the

other. If not, a conference will be instrumental in giving both a better understanding of the problem. The solution may be that each teacher will take time to give special instruction in the method to be used in his courses.

Certain ideas and processes may be ever so important from the point of view of one department but receive little or no attention in the other. It becomes necessary therefore to determine the department which should provide the instruction. To illustrate again, high school mathematics generally uses data that are to be regarded as exact. Approximations are used less often. They occur in problems for which the data are derived by actual measurement. The question comes up also in connection with the use of tables containing approximated values. Hence it is necessary that the mathematics teacher pay attention to some aspects of the idea of approximate value. Other phases which occur rarely in mathematics may never be touched upon. If the science teacher is not fully informed about the content of the mathematical courses, he will make the mistake of assuming that understanding is complete and when he finds that this is not the case he criticizes the mathematics department. For example, the idea that certain quantities entering into a computation are so small, comparatively, that they may be neglected without any significant influence on the result, is used so little in high school mathematics that it would be unwise to take the time to have it thoroughly discussed. As long as it can not be brought to the pupil in a number of genuine experiences it would practically have to be forced upon him. The better plan is to introduce the idea when it appears in the study of science and to develop it like any other new concept.

The foregoing criticisms are not nearly as disturbing to the teachers of mathematics as the insistent complaint of science teachers that pupils have not mastered even the simplest facts and processes of mathematics. A few examples illustrate this type of criticism. It is asserted that pupils can not solve such equations as $s=a+vt$, and $s=\frac{1}{2}gt^2$; that they have little or no knowledge of the meaning and laws of simplifying fractions; and that they do not know the laws of signs. In fact, there are complaints about almost everything that is taught in high school mathematics. Poor teaching is probably in many cases responsible for those difficulties. This fact can not be overlooked by the mathematics teachers and they should leave nothing undone that gives promise of securing better results.

It has been found, however, that even the best teaching does not necessarily remove the difficulty. Pupils who have no trouble at all with solving $s=\frac{1}{2}gt^2$ when it occurs in the regular mathematics lessons may fail when it comes up in the physics classroom. The introduction of physics problems in the teaching of mathematics is of considerable help, provided the concepts of physics which enter in such problems are clear. Teachers of mathematics find that usually this is not the case. Pupils have difficulty with the ideas of physics when they occur in mathematics for the same reason that they have trouble with mathematics in physics. The explanation lies in the strangeness of the situation rather than in lack of previous training. Teachers do not always realize what a difference a change in the situation makes in the pupil's work. When our best friend passes us on a busy street without the slightest sign of recognition we do not accuse him of ignorance. We know very well that the cause of failure to recognize us is the unfamiliar environment which absorbs his attention so completely that we appear no different from any of the strangers who pass by. In the same way $s=\frac{1}{2}gt^2$ in mathematics is something very different from $s=\frac{1}{2}gt^2$ in science. Indeed, pupils in science may look upon the s and t as abbreviated words rather than as number symbols. They see in the equation only an abbreviated statement of a rule and not an abstract number relation. Hence, the teacher of science must connect the unfamiliar $s=\frac{1}{2}gt^2$ of science with the familiar $s=\frac{1}{2}gt^2$ of mathematics. If he fails to assist the pupil to take this step because it belongs to the field of mathematics he may be justly accused of teaching science badly. For the time being he must become a teacher of mathematics. When a pupil is confused as to the way of solving $s=a+vt$ for t, it takes but little time to show that the equation is no different from $x=2+3y$ and that the laws for solving both equations are the same. It is evident that it requires the cooperation of the two departments to solve the problem. In mathematics the pupil should be given applications from the field of science, and the teacher of science should give instruction to supplement the pupil's mathematical training. The science teacher thus assumes definite obligations in the program of teaching mathematics. He is ready to teach or reteach the mathematical facts and principles which are used in science and which have not been sufficiently mastered. The chances are that science will gain as much by this arrangement as mathematics. Mathematics defi-

nitely related to science will contribute to a better understanding of that subject.

Various ways of dealing with the problem of mathematics and science have been recommended. One of the most drastic is to minimize or eliminate from the science courses such phases of the sciences as can be taught well only by use of mathematics. From the point of view of the learner the demathematizing of science courses is the wrong way of solving the problem. It widens the gap between two related fields. It moves in a direction opposite to that of the present trend toward integration.

Another extreme recommendation is to throw the responsibility for the mathematics needed in science entirely on the teacher of science. This is part of a general plan to abolish the formal teaching of high school mathematics and to let each subject provide for the mathematical needs of the pupils. This solution of the problem was seriously advocated several decades ago but failed to make any progress. However, it is being revived at the present time. It is sure to fail again. Only those who have attempted it know the hopelessness of the efforts of the teachers of science who try to teach factoring, the fundamental processes with fractions, or the solution of the quadratic equation to a class of pupils who are not thoroughly grounded in the elements of algebra and who know little or nothing about the meaning of coefficients, exponents, signed numbers, quotients, and equations. The theory of letting each teacher teach the mathematics as they are needed in his course does not take these difficulties into account.

The third plan tries to avoid extremes by coordinating the activities of the departments of science and mathematics. Some go as far as to advocate the merging of the two subjects into one. The method is being used with success in some of the European countries. At every level of the secondary school period the same instructor who has charge of a group of science pupils also teaches the mathematics. He is therefore in the position to know exactly what has been taught in both subjects and what the pupil may be expected to do. The pupil, on the other hand, can not evade responsibilities by blaming his lack of knowledge of poor teaching. Duplication and loss of time are reduced to a minimum. Mathematics is made a real help in the study of science and applications taken from science are the rule in mathematics teaching rather than the exception.

In this country there are probably few schools in which it is

possible to merge the two departments. There is no reason, however, why the activities should not be much better coordinated than is customary. The time to accomplish this was never more opportune than the present. In the past the major obstacle to the plan have been the administrative officers of the school. Now the administrators themselves are beginning to be more than interested. They are indeed advocating the integration of related subjects.

A second obstacle has been the lack of teachers sufficiently familiar with both fields to be qualified to give instruction in them. It also is becoming less serious. The present trend in education is to urge prospective teachers to be prepared to teach at least two subjects, and school officials usually give preference to candidates for positions who are qualified to teach in more than one department. Mathematics and science is a favored combination.

The only remaining obstacle is the attitude of the teachers who prefer to devote their time and effort to one field to the exclusion of all others. They are waiting for evidence to show that any other plan produces better results. It is therefore necessary to set up experiments in a number of centers for the purpose of trying out plans of coordination under carefully controlled conditions. In this the backing and leadership of a strong organization such as the *Central Association of Science and Mathematics Teachers* should be a valuable incentive.

Experimentation has already begun in some schools. It may be of interest to describe what is being attempted in the University of Chicago High School. In this school the integration within the field of mathematics has been accomplished. Until this year one year of general science and one of correlated mathematics were required for graduation. Both courses were finished in one year. In the new plan the work will be distributed over three. Five periods a week will be allowed for it. The five periods per week will be divided between the two courses. For the present two periods have been allotted to one subject and three to the other. The amount of subject matter to be taught will determine which department should have the two periods and which the other three. This year science has been given three days and mathematics two. Occasionally the time allotment may be reversed. As far as possible the courses will be so organized that mathematical processes and principles are taught before they are needed in science. This will be

facilitated by deferring some topics of science to the time when the necessary mathematical knowledge has been acquired. The details will be worked out as the courses proceed. Since the required work has been distributed over a period of three years, the elective courses such as physics, demonstrative geometry and others, will be taken up later than has been the custom in the past. Five periods a week are allotted to each of these courses. It is too early to present data on the results of the experiment, but the start has been made and some interesting outcomes are expected. Difficulties are certain to arise, but ways will be found to eliminate them.

If similar experiments were tried out in schools which are in the position to do experimental work of this type a great deal may be accomplished. The details of the plan should be worked out by a joint committee of teachers of both subjects. Meetings will have to be held at regular intervals and changes should be made promptly as soon as the need for them is recognized. The committee should determine the mathematics needed in the science courses and when they should be available for use.

If any of the teachers are qualified to teach both subjects they should be given classes in both. However, there is no reason why the teaching could not be done by members of both departments.

Because of the correlation of mathematics with science the laboratory method should have a prominent place in both subjects. It will be especially helpful in the development of mathematical concepts and in the discovery of fundamental principles of algebra and geometry. The practical values should receive much attention. Abstract principles should be made concrete, and emphasis should always be on understanding rather than on mechanical performance.

If the teachers of mathematics have had no experience with the laboratory method, the experimental work may be done by science teachers and the problem work may be turned over to the mathematics department.

Summary.—In the foregoing pages it has been shown that there are important reasons for reorganizing the contents of high school courses as, for example, the elimination of waste due to duplication of subject matter and to the artificial separation of the various fields of learning.

As the best solutions of the problem have been suggested the

correlation of the instructional materials belonging to the same field and the coordinating of the teaching activities in related fields.

The results to be expected are elimination of waste of time and effort, broader training of the pupil, and better understanding among departments.

Suggestions have been made as to plans of coordinating the activities of the departments of science and mathematics, and the hope is expressed that the *Central Association of Science and Mathematics Teachers* will sponsor experimentation with the problem.

ANOTHER SUGARING OFF

Dr. Wm. Vinal
School of Education, Western Reserve University, Cleveland

HEAR YE! HEAR YE! There being no sugar canes in this Ohio country and there being no lack of sugar in the forests we beseech ye to hie once again unto Hudson Town for ye big gathering and frolic. Those trees called maple supply that wholesome liquor which, being boiled up and evaporated, turns into a kind of sugar somewhat brownish but very good. The women will busy themselves in receiving the liquor into vessels of bark when it trickles from the trees. The first that comes is the best and there are those amongst us who declare that there is none better than that yielded up by these trees of Summit County. It will then be dragged to the sugar house in ye stone boat. Hi Simons of the old academy will be master of ceremonies at the "bilin' down." And there is much talk that there will be other carryin' on's when ye school teachers will gather specimens and take a trees-in-winter hike led by that ancient mariner, "Cap'n Bill." From 5:00–7:00 P.M. by the Academy Bell all those who feel so inclined will gather at ye old meeting house for food and sustenance.

Wampum to the currency value of 50 cents will be acceptable up to high noon Wednesday, March 15th. This should be sent to Cap'n Bill, Western Reserve University School House, school of Education, Cleveland, Ohio. Please attend to this promptly that ye women may provide large enough caldron kettles for the repast and that ye men of the village may whittle sufficient maple paddles for all.

Following supper Cap'n Bill will show a new set of lantern slides on the "Gathering of Sap." These colored views taken in Hi Simons own sugar orchard may be borrowed by school masters wishing to use the same in their studies. It is also hoped that some pedagogues will put on a skit that will make much merriment for all.

Last year (1933) there were plenty of hi jinks in the morning ending with yarns spun by Mayor Waite. Head master Joel Hayden, of the Academy has invited the science teachers hereabouts, through the Central Association of Science and Mathematics Teachers, to the second round up at the Western Reserve Academy, Hudson, Ohio. Mr. E. O. Bower of East Technical High School is appointing a local committee to formulate the morning program and the afternoon will be cared for by members of the Nature Guide School which is holding its fifth reunion at the sugar bush.

Look for further details of the program in the March number of School Science and Mathematics.

THE GOAL OF A PHYSICS TEACHER*

By Arthur L. Foley
Professor of Physics, Indiana University

Some time ago while talking to a prominent business man I mentioned the fact that a large per cent of the students (most of them sophomores) entering my first year physics class were unable to add 3/5 and 4/7. "Well, why should they?" he asked. I was stumped. What could I have answered that would have satisfied a hard-headed practical business man who had for many years conducted an honorable and successful business, and who was a wide and intelligent reader in the fields of religion, general science and politics? I do not know whether or not this man could have added 3/5 and 4/7. It is obvious from his question, however, that in his business life he had never had any occasion to add such fractions, and further, that he would not have been distressed in the least had he been unable to do so.

Suppose I had answered that business man by saying that I am a physics teacher, and that physics can not be done well by students deficient in arithmetic. Then he might have asked me why students should study physics. Having pondered over this question for a third of a century, I might have recited to him the several reasons (or shall I say excuses) that have been advanced at one time or another to justify physics courses in high schools and liberal arts colleges, and to entice students to enroll in physics classes. Nevertheless, had the point been pressed, I would have been forced to admit that the majority of students graduate without ever having taken an hour's work in the subject of physics, and that they do not seem to regret the omission. And by "they" I do not mean the young graduates who have not been out in the cold world long enough to form any worth-while opinions on the question. By "they" I mean graduates of ten, twenty, thirty years standing who think they know the factors contributing to their successes and failures. These are the people who can most intelligently evaluate our work. But whether they do it intelligently or not, they certainly are weighing us in the balance. We have no right to object to their doing so, for they are the taxpayers who must dig down in their pockets to pay our salaries and equip our laboratories,

* Abstract of an address to the Physics Section of the Central Association of Science and Mathematics Teachers at Chicago, Dec. 1, 1933.

and who supply the children for our classes. Why study physics?

Bearing on this question I wish to quote freely from two papers published in the *North Central Association Quarterly* for September, 1929; one by Professor Hurd of the University of Minnesota on "Reorganization in Physics," the other the address of Mr. W. I. Early, the retiring president of the Association. Professor Hurd says:

> 1. The course in physics should add to the pupil's knowledge as much as is feasible about the physical world in which he lives, so that he may use it in his every day life to make him more efficient socially and vocationally.
>
> 2. The subject material should bear upon his necessities and his experiences in daily life.

Note that practical knowledge is the goal set forth in the quotation.

Now let us turn to Early's paper, in which the author gives the results of a questionnaire sent to two hundred college teachers asking them to name the "three most valuable traits in a beginning university student." Sixty-five qualities were named.

The ten qualities receiving a comparatively outstanding number of votes were, in order, as follows:

1. Industry
2. Intelligence
3. Having a worthy objective
4. Desire to learn
5. Intellectual curiosity
6. Ambition
7. Intellectual honesty
8. Will power
9. Study habits
10. Initiative.

Observe that scholarship does not appear in the list. Of a possible six hundred votes scholarship received but seven.

Early summarizes the vote in the statement that a student going to college is a safe college risk if he has "a worthy objective, the gray matter to warrant the choice, and the character to see it through." Why the words "college risk?" Is not such a student a good risk whether or not he goes to college? Worthy incentive, gray matter, character. What better qualifications could one name for citizenship? Note, however, that the objectives named by Mr. Early are the result of an educator's attempt to draw a worth-while conclusion from sixty-five different votes; to find amongst sixty-five objectives the

ones on which there is the most general agreement. The only objection I offer to such studies, and there have been many of them, is that many teachers regard too seriously the conclusions drawn from them. Because the majority of teachers are agreed upon certain objectives and certain methods of teaching is no indication of the infallibility of either objectives or methods, and certainly no excuse for laws and regulations to force other teachers to adopt them. A glance at what has happened in the field of physics during the last half century is sufficient to substantiate the above statement.

A century ago graduation from college meant courses in Greek, Latin, mathematics, and either mental and moral philosophy, or natural philosophy, as the subject of physics was then known. All courses were taught from the mind discipline viewpoint. There was little or no experimental demonstration in natural philosophy classes, and student laboratory work was all but unknown.

As science laboratories began to develop and business colleges sprang up everywhere there came into prominence the phrase "practical education." This caused many teachers to shift the emphasis from the disciplinary to the factual value of science education. Many others refused to abandon the disciplinary viewpoint, but their ideas of what disciplinary training should embrace developed until they included training of the hand and body as well as the mind. So laboratory work and vocational training were stressed everywhere. The laboratory idea was so popular that many teachers of such subjects as history and language claimed they were teaching their subjects by laboratory methods. Many high school and college physics classes came to be little more than trade school classes. The student was to be trained "to intrepret his environment—not to mold it; to imitate—not to initiate; to think in terms of and to live in his own little world of trivial every-day experiences rather than in the light of the wisdom of the great and good of all time.

The tenet that the subject matter in physics should bear upon the pupil's necessities and his experiences in daily life is certainly not in accord with the injunction to "Introduce children to big ideas, and do it early," a conclusion accepted by the National Committee on Science Teaching and published in the 1932 Year Book of the National Society for the Study of Education.

The Committee tells us that "An aim of education that seems consistent with the postulations of modern philosophy is *Life Enrichment through Participation in a Democratic Social Order.*" One may wonder where he is to find that democratic social order of which the committee speaks. However, granting the possibility of such a state, certainly no one can question the Committee's conclusion. But the enrichment of life, enabling one to "have life and have it more abundantly," is not the function of the school alone. Is it not the supreme function of the home and the church also? Differences of opinion prevail only as to the specific means by which life enrichment is to be secured.

The contributions which science may be expected to make to the solution of the problem are summarized by Professor Meister[1] in what he says has been "the goal of education which has seemed acceptable ever since the World War." Important generalizations of science "have come to function in at least three ways. (1) They constitute a body of knowledge which must be experienced and mastered, (2) they represent a method of thinking which civilization has had to adopt for its own preservation, and (3) they indicate a set of habits and attitudes which insures future progress."

I am not certain what it means to "experience a body of knowledge," and as to mastering the subject of physics I realize that I am a long way, a very long way, from that objective. Further I never expect to reach it, and I do not expect anyone else to reach it. Physics is not a static subject.

Referring to the second point, that science "represents a method of thinking which civilization has had to adopt for its own preservation," I would inquire—when did civilization adopt it? When people plant potatoes, wean calves and shingle houses in the dark of the moon; when three is lucky and thirteen unlucky; when people shy at black cats and Friday, and continue to squander money on fortune tellers, self-styled seers, electric pads and magnetic finger rings; when they insist on locating water by the use of a forked stick; when they fall for all sorts of fakes and fakers—particularly in the fields of medicine, religion and politics; when a thousand page book is required to tell us about superstitions that still persist, and when statistics indicate that the vast majority of the people of the civilized world are

[1] Meister, Morris. "Recent Educational Research in Science Teaching." SCH. SCI. AND MATH. Nov., 1932, pp. 875–889.

even today more or less superstitious, I can not believe that scientific thinking is so common amongst our people that one can attribute to it the preservation of our civilization. I recall the fact that there were several ancient civilizations that reached a very high state of perfection in certain fields. I have never known anyone to attribute the decline of those civilizations to their lack of scientific thinking.

To the third point, that scientific "methods and habits of thought insure the future progress of civilization" I can not agree. I think the work "insure" is too strong, and that for it some such phrase as "is needed for" should be substituted. Science alone, in my opinion, can not and will not perpetuate civilization and *insure* its progress. Religion is a force, a factor that must not be ignored or belittled.

Meister's summary

"Body of knowledge"
"Method of thinking"
"Habits and attitudes"

does not stress the value of *thinking* as does the report of the National Committee, previously cited. Quoting from the latter the objectives (of science education) "may be formulated.

1. As statements that function directly in thinking.
2. As statements that describe methods of thinking,
3. As statements that describe attitudes toward product of thought and toward methods of thinking."

One's first impression might be that the objectives named by the Committee can be summarized in a single sentence—the ability to think hard and straight—and that all other objectives have been rejected entirely. However, such a conclusion is not wholly justified. How can one think hard and straight unless he has some facts and principles on which to base logical thinking? How can he think logically unless he has a trained mind? I am willing to concede that thinking is the primary goal in science teaching, but I am unwilling to admit that factual knowledge and mental discipline are not secondary objectives that are necessary for straight thinking.

A friend touring the south noticed that many of the women in a certain locality seemed to spend most of their time sitting on the front porches of their little homes, in apparent idleness. The question "how do you spend your idle time," brought the answer "Well, sometimes we set and think and sometimes we just set." Do not most people prefer just to set? Brisbane says

that people would rather do anything else than think. Hitler, Mussolini and others like them do the thinking for their followers, and their followers like it. We would not be in such a sorry mess today, our educational system in common with all the rest, had our people carefully weighed the facts and the evidence and done some straight thinking before forming their conclusions.

The situation in the industrial and financial world is but little less chaotic than in the realm of science,—particularly in the field of astronomy, with physics a close second. Too many have, in fact if not in name, become speculative philosophers. Too many have turned their imaginations loose, practically unrestrained by such common-place things as facts and experiences.

I was once present at a science round table discussion at which a certain professor made some startling assertions concerning relativity. His views were promptly attacked by the late Professor Michelson, who was present at the meeting. An Atlantic seaboard professor became quite excited in his efforts to support his friend. Amongst other things he said that we do not know that the sun is 92 millions of miles away, that we do not know that it is 2 millions of miles away, that we do not know that it is 2 miles from the earth. When a man begins to talk that way I begin to look for the door and map my route so that I can make a quick get-away in case he suddenly becomes violent. Perhaps it would be just as well for us "just to set," as to think without a factual basis for our thought, particularly if we try to induce or to force others to accept conclusions which are the product of such thoughts.

Whatever be the goal of science teachers may we not agree on this point—that it is necessary that a student be interested in what he is studying? If not interested he will study very little or none at all.

"You may lead a horse to water but you can not make him drink."

You may send a boy to college but you can not make him think.

But in most cases one can induce him to think. It is a question of finding some subject in which the boy is interested, and of encouraging and developing that interest. If, as sometimes happens, there is nothing in physics that appeals to him, then he should not waste his own, his classmates', and his teacher's time by remaining in a physics class.

In the language of the late David Starr Jordan, "one can not pin a three thousand dollar education on a thirty cent boy." I agree, but I must not be too sure a boy is a thirty center because he fails in my work. The failure may be due to a lack of interest rather than to a lack of gray matter. However, if a good teacher has tried hard to arouse the student's interest, and failed (he certainly would not be a good teacher if he did not try hard), the teacher should not be held responsible for the failure.

A few years ago in an address before the State Teachers' Association meeting at Indianapolis I heard a well known bishop make a comparison from which his audience was supposed to draw a conclusion, and many of them did—in my opinion an utterly false conclusion. He was talking about the teacher failing students who do not come up to certain standards of scholarship. He condemned such teachers. What would you think, he said, of a carpenter who could not build houses without having some of them fall down or otherwise fail? Actually, there were teachers who cheered that utterance. If a carpenter were given fifty piles of material, all good first-class stuff, of course we would condemn him if any of his houses failed. But if the material in some of the piles was knotty, twisted, decayed, the carpenter could not be expected from such material to build houses that would not fail.

If we should apply to the bishop the test he would apply to teachers, then the bishop as a minister is a failure. He does not make Christians of all who hear him preach. Christ himself did not do so.

Before passing from the subject of interesting the student I wish to say that I have been studying this subject for a quarter of a century—particularly during the past ten years. I have had a double incentive. In the first place, I wanted to make our laboratory work at Indiana as interesting and as permanently helpful to our students as possible. In the second place, I have had in preparation a physics textbook and wanted to include in it those topics that students of this generation find most interesting and those which were most appealing at the time and have been most helpful since to those who took work in physics with us or elsewhere a generation or more ago.

On the completion of a term's or a year's work we ask each student to list the topics he found most, also those he found least, interesting and instructive. We give each student a list of all the laboratory experiments he has performed and ask him

to number the experiments in the order of their interest, and again in the order of their educational value to him personally. In the preparation of textbooks and laboratory manuals, and in our lectures and laboratory assignments we are guided to a considerable degree by the results of the above questionnaires, and by correspondence and personal talks with former physics students. The net result is that some textbook and lecture topics and a number of laboratory experiments previously given have been eliminated entirely. A few experiments have been made entirely optional, and some new ones have been added. The entire list has been divided into groups, the student having a choice of one or two experiments from each group. We are still a long way from our goal, but we believe we are making some progress.

Let us not forget that in his early years Newton was a very backward pupil, so backward that some of his teachers regarded him as somewhat "subnormal." At college he cut classes in subjects in which he was not interested and spent the time lying under a hedge inventing the calculus. Think of it!! A student inventing calculus, a subject which the vast majority of college students today are afraid to tackle, although mathematicians for centuries have tried to improve "calculus simplified" textbooks. The "subnormal" boy who played "hookey" became Professor of Mathematics in Cambridge University when only 26 years old, and is generally recognized as the greatest intellect the world has ever produced.

Let us not forget that Galileo was sent to college to study medicine and the classics, that he neglected these subjects to hide behind the classroom door to listen to recitations in mathematics—a subject he had been forbidden to study. Galileo remained at the college four years, but was refused graduation and was refused a free scholarship offered to those deserving students who wished to pursue graduate work,—refused because he chose to question the opinions of some of the group of fossils constituting the professorial staff. The "Father of Physical Science" refused graduation! The world does not know the names of those who were graduated.

The world would never have heard of either Newton or Galileo had their training been "standardized."

Eleven years ago I published a paper[2] giving the results of a

[2] School Science and Mathematics, Vol. XXII, No. 7, Oct., 1922.

study of the question of the knowledge of physics possessed by high school students enrolling in beginning college physics classes. The study was conducted in ten Indiana colleges. Of several conclusions drawn from the results of the study, the one most vigorously attacked was the statement that at the time they enroll in college physics classes, in knowledge of the subject matter of physics there is little difference between those who studied physics in high school and those who did not, and further—that the former group shows but little superiority over the latter in their college work in the subject. The conclusion, in which all ten of the physics teachers engaged in the study concurred, was promptly challenged. I observed, however, that almost all the criticisms were voiced by men who had never taught a physics course. I observe with some satisfaction that the conclusions arrived at in that Indiana study eleven years ago have been substantially verified by later studies. Note what Professor Hurd says in *School and Society*, April 5, 1930.

"The tendency for high ratings for students having high school physics is evident, but the value of the high school course is not so marked." "Considering all the data . . . while there seems to be a tendency for students having high school physics to do better work in college physics, it is not so marked. The possibility of other students doing about as well is more noticeable, because one would rather expect the high school course to show up more favorably."

Some conclusions which I wish to question are stated by Professor Meister in his paper from which I have previously quoted. Quoting again—

"Those who work in the field of science education should dedicate themselves to the proposition:

(a) That there is such a thing as artistic teaching; (b) that the outcomes of artistic teaching can be measured in terms of pupil learning; (c) that the procedures employed by artistic teachers can be analyzed and made the basis for a science of teaching; and (d) that progress in science teaching can come only by an acceptance of this science of teaching by all teachers of science."

Considering these propositions in order—

(a) That there is such a thing as artistic teaching is certainly true. As to whether artistic teaching is the best kind of teaching we agree or disagree, depending on the interpretation of the word "artistic." If artistic teaching means effective teaching, inspiring teaching, we agree. But if artistic teaching means

teaching by standardized methods and cut and dried procedures, we assuredly disagree.

(b) With the proposition that the outcomes of artistic teaching can be measured in terms of pupil learning I can not agree, whatever be the definition of "artistic." I hold that the outcomes of teaching of any kind can not be measured satisfactorily in terms of pupil learning, assuming that the extent of the learning is gauged by grades made on examinations or tests during or at the end of the physics course. *All of the outcomes do not come out during the school term,* not even during the school life of the pupil. How can examinations and tests tell us what the pupil has acquired that will "function directly in thinking," "describe methods of thinking," or "describe attitudes toward products of thought and toward methods of thinking," the three objectives named by the National Committee. The usual test shows us practically nothing concerning the student's capacity to think. It does show us what he has committed, most of which, as numerous studies have definitely proved, the student forgets in a few months after the test. Do not misunderstand me. I am not opposing examinations with nothing to propose in their stead. I am saying that the benefits one may receive from the study of physics are far too subtle to be measured in percents. My conclusion that high school students who have studied physics know but little of the subject when they enter college does not mean that their high school course was a failure. A "Body of Knowledge" may be forgotten in a few months or years, but "Methods of Thinking" and "Habits and Attitudes" persist through life.

It is because I feel that the usual tests do not tell the whole truth that I do not accept unqualifiedly conclusions based on such tests. For example, we are told that physics students get as much from seeing experiments performed by the teacher as they get from performing the experiments themselves; that class demonstration is as good as individual laboratory practice. Certainly, perhaps much better if measured by an examination at the end of the course. Still better grades would result if *all* experimental work were eliminated and each student were supplied with a book of questions with the answers printed immediately under the questions. But, is laboratory work primarily to teach the facts of physics? Does the student get from his laboratory practice no skill, no insight into methods, no initiative, no training in independent thinking? Does an examination

tell us how much the laboratory has done to awaken or strengthen these faculties, an examination in which all a pupil needs to do is to match words or to supply here and there a missing word or phrase to complete a sentence, never himself being required to evolve an idea of his own and express it in words? To pass such an examination a pupil must bring his memory to the class, his thinking apparatus he may leave at home. Let us not condemn laboratory work until we have *reliable* data on which to base our conclusions.

The third proposition "That the procedures employed by successful teachers can be analyzed and made the basis for a science of teaching:" and the fourth, "That progress in science teaching can come only by an acceptance of this science of teaching by all teachers of science," may be discussed together.

I have long held the view that the best possible training for a prospective teacher is to study under as many teachers as possible, both good and bad. He will find representatives of both classes teaching physics, mathematics, and all other subjects—including the science of education. In so far as possible he should try to discover what procedures are most successful and try to fit them into his own plan of teaching when he later becomes a teacher. But I do not believe that the work of a successful teacher can be adequately analyzed, and even if it could be, I do not believe that all teachers should be required, or even be expected, to adopt his procedures.

How can I analyze what I believe are the most important qualifications of a really successful teacher,—personality, inspiration, enthusiasm, incentive, motives; that inherent something without which one can never hope to become a good teacher. Academic and education degrees can not make an inspiring teacher of one who is not born with a teacher's instinct any more than courses in English can make a poet or courses in physics and mathematics an Edison. Nation wide examinations in physics, mathematics and some other subjects were held a few years ago to find an Edison successor. He hasn't yet appeared.

The late Dr. Jordan was once asked what he considered to be the three most important qualifications of a good teacher. He replied: "The first is a thorough knowledge of his subject, the second a comprehensive knowledge of the subject, the third is like unto the first." Notwithstanding his emphasis of academic training and his apparent rejection of other qualifications,

Dr. Jordan was one of the most inspiring teachers I ever knew. I cite as proof of this statement, *not the grades* made by his class at the end of the term, but the *records his students have made in the art of living*. This is, in the final analysis, the criterion by which the success or failure of teachers should be judged. That "the proof of the pudding is in the eating" is no truer than that *the test of a teacher is in the character and lives of the men and women who were at one time his students.*

May we not recognize the science of education as giving us guide posts without accepting any millstones? The moment we adopt definite procedures and cut and dried methods, we cease to grow. We lose our ambition, our initiative, our ability to inspire, and become automatons.

An automobile can be made successfully by a machine because the materials supplied the machine can be maintained uniform, but pupils can not be successfully taught by a machine, or by standardized methods. Children are as unlike in their environments, inheritance, aspirations, in all their faculties, as day is unlike night. A teacher who does not have the courage and the energy to adapt his procedures to the particular class he is teaching and to his own talents and limitations is, in my opinion, a very poor teacher. As a matter of fact, successful procedures must *change with the times.*

One of the factors that has contributed much to the woes of the physics teacher of today is the marvelous mechanical development of the age, the very thing that on first thought would be supposed to arouse intense interest in the study of physics. Of all these achievements the moving picture is the most baneful.

When I was a college student the whole student body turned out and listened attentively to a lecture if illustrated with a few lantern slides. The physics teacher could secure the undivided interest and attention of his class with an experiment of the simplest kind. How about your lantern slides now? How can you expect plain talk concerning a plain lantern slide of, say, a bridge truss or a galvanometer diagram to compete with a sentimental song, each line illustrated with beautifully colored pictures and accompanied by the appealing strains of a wonderful pipe organ that seems to pronounce the words of the song in perfect accord with the singer.

How can you interest a student in the story of the weights Galileo dropped from the Leaning Tower when he himself has seen (rather he is fooled into believing that he has seen) the

screen hero jump from a cliff a thousand feet high or from a racing automobile to a racing locomotive? How can you interest him in the rise of water in capillary tubes, the law of falling bodies, or the swing of a pendulum, when he (fooled again) has seen the Hollywood(en) hero scale the vertical wall of a twenty story building, fall apparently to certain death, catch the hand of a clock and swing back and forth hundreds of feet in the air? The facts are that the radio, the automobile, the airplane, the talking movie, have satiated our people. We have lost our curiosity, our desire to know why. Every day we are growing more insensible. The moving picture reel that held us spellbound twenty years ago would be hooted off the screen today. Thrills of the most hair raising type are demanded, and even these are losing their power to thrill.

In the face of all this, how absurd it is for educators to tell the physics teacher that he should deal with things that the pupils know something about already, things that are within the range of their experiences. How absurd it is for them to tell us that we can interest our young people in motors but not in molecules, in electric irons but not in electric ions. As a matter of fact, exactly the reverse is true. The familiar and commonplace have lost their interest. One can secure more interest in the study of electrons than in the study of electric fans, in the solar system than in a heating system.

One more reference to the moving picture. I have heard it predicted that most of our colleges and high schools will in a few years be but a memory. The proposal is to set up a national institution at Washington where only the very finest teachers and lecturers will be employed to broadcast to every hamlet and practically every home, thus giving to all high school pupils and university students the advantage (?) of the best of the teaching profession. Bosh! you say, all the product of the imagination. Let us not be too sure on this point. If the tax payers once get the idea that the thing can be done and that a great saving in taxes would result, no telling what might happen. In fact, is not our entire school system in jeopardy?

In the face of the situation which confronts us today, what are we going to say about our own subject physics? Do we know that the number of doctorates in physics when compared with most other subjects, has been on the decline for the past thirty years? Do we know that physics classes in colleges and high schools in which physics is an elective subject have for several

years decreased in numbers relative to the total enrollment in the schools? Well, these are facts. What are we going to do about it? It is up to us to do more than we have been doing in the past. We get nowhere by trying to shift our responsibility. I beg to quote an amusing illustration of this practice. The quotation is from Mr. Early's paper previously cited:

The College President:
Such rawness in a student is a shame,
But lack of preparation is the blame.

The High School Principal:
Good Heavens! What crudity! The boy's a fool.
The fault of course is with the grammar school.

The Grammar Principal:
Would that from such a dunce I might be spared!
They send them up to me so unprepared.

The Primary Teacher:
Poor Kindergarten blockhead! And they call
That "Preparation." Worse than none at all.

The Kindergarten Teacher:
Never such lack of training did I see!
What sort of person can the mother be?

The Mother:
You stupid child! But then, you're not to blame;
Your father's family are all the same.

It is the old, old, story, giving an excuse instead of a reason, an alibi instead of a remedy; in terms of Twentieth century slang—it is just plain "passing the buck." We must do more than this or hunt new and different jobs.

Quoting again from Professor Meister's paper—"The remedy for poor science is more science." I do not admit that our science is generally poor. But if it is, the remedy is to make it better or to abolish it. We have no right to expect burdened tax-payers to give us more money to inflict on them more teaching of an inferior quality. Regardless of whether or not we expect them to do so, we may be very sure that they will not do so.

I can not understand why any one should propose, particularly when people are in their present temper, that "the remedy for poor science is more science." One might as well say that the remedy for the depression is more depression, for crime waves is more crime waves, for divorce is more divorces, for poor teachers more poor teachers.

THE CHEMISTRY TEACHER AND THE REDUCED BUDGET*

By B. S. Hopkins
Department of Chemistry, University of Illinois

American education faces the most vital crisis of its history. From every quarter comes reports of shortened school terms, over crowded classes, curtailed curricula, abandoned laboratories and school systems without the financial support necessary for their operation. Schools do not have adequate maps, charts and scientific equipment; teachers are unpaid or paid in part by various forms of scrip; public revenues have fallen to unbelievably low levels; the tax system has failed to function properly or has broken down altogether; school districts have defaulted and our compulsory school laws have become a mockery because it is impossible to provide educational facilities for children who should be receiving daily training in the fundamentals of education, as well as in the basic essentials of right living and good citizenship.

Under these distressing conditions what is the duty of the educators? It is obvious that little can be gained by complaint, or pessimistic fault finding. Our first duty is to recognize the seriousness of the situation and our second obligation is to do our best to apply remedies wherever suitable opportunities present themselves. We must remind our patrons that the entire American system of government with its manifold institutions is based upon the idea of an educated and discriminating general public. We must insist on a recognition of the principle that the most sacred obligation resting upon any generation is the provision of adequate training for its young. The failure of our present educational system will most certainly mean enormously greater expenditures in the future for criminal courts, police officers, and prisons. A generation of youth which is allowed to reach mature years without education and training in the proper ways of living under modern conditions, means that crime will run rampant, that industrial slavery will return, that we will be threatened with a return to feudalism and a general collapse of the civilization of our day.

This is a gloomy picture, but we need to be aroused to the seriousness of the situation before it is too late to apply reme-

* Read before the Chemistry Section of the Central Association of Science and Mathematics Teachers, Dec. 1, 1933.

dies. The educator must turn diplomat and with skillful adjustment to his local conditions he must extend his influence to the adult population of his neighborhood. The parents of his pupils should know the situation and the dangers that impend. It is wise also to remember that the child of today becomes the man of tomorrow and certainly those who come within our immediate influence should be taught the lesson of proper living as well as the science, the mathematics or the literature which form the subject matter of our daily tasks. Before we realize the rapid flight of time our pupils of today will become the leaders of tomorrow and we have a right to rely upon them to safeguard those institutions which we have come to regard as the vital defenses of civilization against ignorance, crime, industrial slavery and chaos.

The present author is both a teacher and a public school official. As a consequence he is able to see more than one aspect of the situation. As a teacher he knows all too well the deplorable conditions which beset some of his coworkers in the field of public education. As a member of an educational board he knows something of the reasons why we find ourselves facing so serious a crisis. Like so many other organizations in the post-war period we have been living too high. We have spent beyond our means to pay. As a result economy is necessary and it is being applied with a ruthless hand. If I know the American teacher after over a half century of contact with him, I know full well that he will never object to true economy, when circumstances make necessary the most careful expenditures. But he should object and object strenuously when all the economies of a generation are heaped upon its educational system. He should demand that federal, state, county and municipal governments should practice economy as real as that demanded of the public schools; that other salaries than his own should be decreased; that economies in education should not be greater than the private economies in the use of tobacco, chewing gum, cosmetics and other luxuries of this type. If the public school system must return to the level of 1908, then it is fair to demand that the general public also return to the same level in its other standards of living as exemplified by its selection of foods and clothing and its means of entertainment, of travel and of general living conditions. But when the cry of "economy" in the schools is used to conceal extravagance, waste and corruption in other branches of government, it becomes not only the privilege but the duty of

each educator to protest in the name and for the sake of the younger generation whose training has been entrusted to his care. It is a shameful spectacle to see needed teachers dismissed without cause or warning, while at the same time the payroll is increased by the addition of political henchmen under the title of "inspectors," "janitors" or "guards" when such additions are entirely superfluous.

In spite of our feeling that in many localities the public expenditures for education have been subjected to restrictions that are not paralleled by curtailments in other ways, it must be admitted frankly that economy in education is necessary. During the period of postbellum extravagance, the educational expenditures have been excessive and many unnecessary practices have been introduced. No one should object to the elimination of the "frills" and "fads" which are the natural outgrowth of extravagance, if it is possible to retain the fundamentals of education. The great difficulty lies in reaching an agreement as to what those fundamentals are. The education of the general public upon this point is a duty of the teachers which requires careful thought, exhaustive study and diplomatic procedure. If we can agree among ourselves as to the most vitally essential factors in a general education in this century of ours, our testimony with school patrons will have much greater weight. The present author's purpose is to suggest some economies which the chemistry teacher can put into practice, in the hope that others may be ready to suggest other, more efficient methods of dealing with our problems.

It must be admitted that individual laboratory instruction is expensive. If it is to be efficiently administered it requires small classes, costly equipment, and a heavy use of materials which add substantially to the per capita cost. Is it worth while? Is it essential? Are there other methods of teaching chemistry which may accomplish essentially the same purposes without parallel expenditures? The chemistry teacher must face these questions courageously, because it behooves us all in times like these to cooperate in the fullest measure for the maximum good of the cause we sponsor. We must be prepared to accept our share of economy and it is far better for us to do our own reforming than to have it done for us by those who have neither the understanding nor the sympathy which the case requires.

The author wishes to express again with full emphasis his firm belief in the educational value and necessary character of

individual laboratory instruction for those students who are planning a career in chemistry or an allied science or in medicine, dentistry or similar occupations. For such students the training of the hand is vitally important and the skill derived from the individual laboratory work can find no satisfactory substitute. Success in these lines requires the best technique possible and there is no way to win success except by long and thorough training in handling the tools of the trade.

But we must recognize the fact that a large proportion of our pupils do not need such intensive training in the handling of apparatus. For students whose interests are somewhat less professional, individual laboratory instruction may become an extravagance and possibly a nuisance as well. We may be able to fit chemistry more completely to the needs of minds of this type by substituting some other form of instruction than that contemplated by the term individual laboratory instruction.

Group instruction in the laboratory may safely be employed and when skillfully administered this plan will give excellent results. The groups may vary in size depending upon the nature and purpose of the experiment. Two or three make a good working group for the general type of experiment. Larger groups may be expedient occasionally, but personal responsibility and individual achievement decrease rapidly as numbers increase. The obvious advantages of the group system are the saving of material, more rapid progress through a distribution of labor and the possibility of studying a larger number and greater complexity of experiments.

If a group system of instruction is employed the teacher should be alert to certain responsibilities. Care must be exercised in the selection of groups. Each member of the group should carry his full share of the responsibility for the success of every day's work. A group member who does not do his share is being trained as a social drone in the activities of life. A natural leader in the group is desirable but he should not be permitted to do all the work or all the thinking. It is not always possible for the teacher to make a thoroughly satisfactory grouping of his class at the beginning of the semester when most or all of the students are strangers to him. Accordingly it may be wise to change the personnel of the groups at intervals or even to arrange new groupings for each experiment.

Much of the disadvantage of group instruction in the laboratory may be avoided if the instructor insists that each pupil

study the entire experiment with the same thoroughness as would be expected if he were doing the work by himself. Insistance upon a notebook record which will be independently written and complete in detail while it shows a satisfactory understanding of the purpose, method and conclusions of each experiment, will insure a definite educational advance for every day's work. Such a method of teaching laboratory work requires careful planning, active and constant supervision and regular and thorough inspection of the notebook records. By such means we may be assured of a thoughtful and independent study of each experiment, together with skillful observation of the phenomena involved and intelligent interpretation of the results obtained.

Certain types of experiments lend themselves readily to a plan which may be referred to as a "group demonstration" plan. If an experiment, a little more difficult than the average, is assigned to a group of capable workers, they may be expected to assemble the apparatus and materials and to thoroughly familiarize themselves with the details of the experiment. At a suitable time, this group may be asked to perform their experiment while other members of the class act as observers. All members of the class, performers and observers alike, should be required to make an independent and intelligent record. Such a plan gives an opportunity for intensive training in manipulation for those students who need such experience. Pride in presenting a successful demonstration furnishes an effective motive for careful preparation and the opportunity to ask questions will generally fix the attention of the observers. The plan can be made very effective as a teaching method and it has obvious advantages in saving time, and material, while it stimulates interest and creates a helpful friendly rivalry.

The term "lecture-demonstration" may be understood to refer to a type of laboratory instruction in which the manipulation is performed by the teacher, while the students are expected to observe and interpret the results. Such a method has had numerous enthusiastic adherants who have insisted that this method is a superior one from an educational point of view. Even before the days of depression it was warmly recommended on its own merits. Certainly it requires a minimum of equipment and material, it provides more expert manipulation than is possible when beginners perform the experiments and it permits the instructor to explain the various steps in the process

and to call attention to details which are frequently overlooked. The group should not be so large as to prevent a close view of the experiment and each student should be expected to make an independent study of each step employed. If these conditions are obtainable and the independent notebook record is rigidly required, excellent results may be expected. Reports from those who have used this plan are frequently enthusiastic to a degree which may raise a serious question concerning the ultimate value of individual laboratory teaching.

The great disadvantage in lecture demonstrations, so far as the pupils are concerned, lies in lack of training in manipulation. This can be overcome in some measure by asking certain members of the class to assist in preparing the apparatus and in carrying out the experiment. If these services are given as an award for excellent records, there is developed a competitive spirit which is helpful. The less ambitious students may not be reached by such a feeling, so special efforts may be needed to distribute favors where they are most needed. It must be admitted that this method of procedure shifts the responsibility for the success of the experiments from the student to the instructor. This is fully in accord with the spirit of our times, as is abundantly illustrated by our present political trend. Whether or not this tendency will result in the production of a race of dependents, who will stand in sharp contrast to the generation of independent and resourceful pioneers to which our fathers and grandfathers belonged, is a question which should receive careful thought. It has been charged also that the lecture demonstration does not impress itself on the student mind as deeply as his own experiences. This is doubtless true, especially in certain situations, but if the serious student is held responsible for a clear understanding of the procedure he will undoubtedly follow each step closely and obtain a good general knowledge of the entire picture. Searching questions from the teacher will increase his mental activity. It seems quite likely that he may be made to retain as much of a truly educational value as he generally does from other methods of instruction.

School authorities are quick to see the advantage of such plans and frequently they insist on applications which tend to defeat their entire purpose. Thus it is evident that the lecture demonstration plan does not require as long a period as has been customary for individual laboratory instruction. An easy conclusion is therefore that this method will permit a teacher to

carry more classes than was formerly possible. I am sure every teacher of chemistry is willing to do his part in carrying these extra burdens, but it is very obviously unfair to load down the willing workers with excessive schedules. It must be born in mind that a lecture demonstration is impossible without careful and complete preparation. Many times a complete rehearsal under exact class conditions is essential. Unless the schedule of the teacher allows ample time for assembling apparatus, testing materials and trial runs, the lecture demonstration method may be a complete failure. When preparation time is not allowed, the teacher will be forced to depend on verbal descriptions which have little value. School authorities must be made to understand that demonstrations save time for the pupils, but they demand long and careful preparation on the part of the teacher. As a consequence any material increase in the science teacher's schedule is a serious mistake.

Many expedients have been proposed in the interests of economy. The classes have been made larger. It is obviously true that the teacher of a laboratory science cannot indefinitely increase the size of his classes if he is to do effective teaching. Demonstration methods permit larger classes than can possibly be handled by the plan of individual instruction. But even with a full use of the demonstration, the efficiency of instruction decreases rapidly as the size of the class increases. It must be remembered that inefficient instruction is not economy and when a teacher is so handicapped by large numbers that he can not do his work well, his school executives are guilty of gross extravagance.

In some of the smaller high schools it has been proposed to teach physics one year and chemistry the next. The obvious purpose of this plan is to increase the number of students in each class. The inequality in preparation produced by this method more than offsets any advantages which it may possess. The apparatus which is not in use is scattered or rendered useless, so that in place of a saving in equipment the plan actually produces extravagance. The author firmly believes that the ends of education would be more fully attained if the curriculum were to omit one subject or the other. This procedure will permit adherence to the sane program of doing a limited amount of work thoroughly rather than to attempt more work than it is possible to complete in a satisfactory manner.

It is evident that chemistry teachers face reduced budgets

under a wide variety of conditions. Accordingly no one remedy will apply equally well in all cases. It is likely that the wise teacher will not follow any one set formula, but will use a variety of devices at various points in his program. We must each one study his own situation, find if possible the causes of any conditions which need to be improved and then proceed earnestly, tactfully and courageously to bring about improvements. We must carry on for the sake of educational ideals which have been built up by generations of noble men and women whose lives have been devoted to the training of youth. We must put forward our best effort, even in the face of discouragement and disappointment. We must preserve for future generations those traditions which we have inherited from our forebears, in order that our civilization may continue to bless and enrich the lives of its youth.

ROOTS GROWN IN CULTURE, FREE FROM TOPS OF PLANTS

Thousands of growing root tips have been kept alive and increasing rapidly for over a year, without any attachment to their parent plants, and fed only from an artificial liquid medium, at the Rockefeller Institute for Medical Research, New York. The experiment was described by Dr. P. R. White, before the meeting of the American Society of Plant Physiologists.

The roots used were those of tomato plants. The growing tips were cut off and placed in the nutrient liquid, where they continued to increase and multiply in a manner reminiscent of the famous chicken-heart tissue culture started at the same institution many years ago. One of these tomato-root isolations, Dr. White reported, has produced approximately 20,000 growing points, from an initial fragment less than half an inch long. The ratio of the original bit of material to the resultant growth is expressed by the fraction written as 1 over 10 followed by nineteen zeros, so that there is no doubt that the new growth was made by the roots out of the material present in the liquid medium.

—*Science Service*

In Nov. 1933 on recommendation of the Subcommittee on Questions of Policy the College Entrance Examination Board took action to the following effect:

(7) That a commission be appointed to study the possibility of a comprehensive examination based upon a continuous four-year course in science and that as a first step in this direction the commission endeavor to provide, as an alternative to the usual examination in physics, a three-hour examination devised to test the extent to which the student has brought to the enrichment of a study of physics the facts and principles learned in earlier studies of biology, chemistry, or astronomy.

NATION AGAINST NATION
A Challenge to Geography Teachers*

By Russell Whitaker
Department of Geography, University of Wisconsin

In this day of state and nation-wide planning, we may well recall an old Chinese proverb: "If you are going to plan for one year, plant grain. If you are going to plan for ten years, plant trees. If you are going to plan for one hundred years, plant men." Teachers fall, of necessity, in the group of hundred-year planners. In planning for this and coming generations, it is our task as teachers of geography to make our students thoroughly familiar with the major facts about the more important regions of the world, that they may become properly oriented in their physical and social environment. In dispelling ignorance of geographical matters, however, we must be sure to go deep enough to correct the host of errors and misconceptions on which prejudice, hatred, and misunderstanding of other peoples breed. We must plan for a generation that will far outstrip our own in its possession of the qualities of sympathetic understanding of other peoples and good will toward them.

THE TASK AND THE WORKERS

There are few greater needs, today, than that nations understand and sympathize with each other. When men can fly around the world in a few hours and when the human voice can follow the same circuit in a fraction of a second, when trade binds the whole world together and nations exchange insect pests and song birds, and criminals and college professors, as well as corn and wheat—under such conditions the welfare of one group of people becomes the concern of all. We are all adrift in Space on the great Earth Ball, and we cannot get off, despite fanciful notions about sky-rocket rides to Mars. Shut up in the same house, we must come to a higher degree of sympathetic understanding with the occupants of the other rooms. Neighbors, despite our will perhaps, we must become friends. We are "bound together in the bundle of life," and so intimately are we bound that the interests of one are, to a large extent, the interests of all.

The future of mankind must surely depend, therefore, on the

---

* Read before the Geography Section of the Central Association of Science and Mathematics Teachers, Dec. 1, 1933.

achievement of a greater degree of cooperation. And wholehearted cooperation must be based on a sympathetic understanding of others. We need not of necessity like them as we would personal friends, but we must have some appreciation of their problems, their fine traits, their ideals, if we would rid ourselves of prejudice and hatred, eternal barriers to full cooperation. Human progress will rest in the future, as it has in the past, on the collective efforts of millions of men. To banish war and much of the poverty and sickness which now characterize human society will require the united action of the peoples of all nations.

To this end, it devolves upon all leaders of human thought to displace prejudice and narrowness of view with charitable, open-minded attitudes. Men are not born with prejudices. They absorb them from their social environment. And the social environment can be changed. It has changed in the past, again and again. Newspapers are among the more potent factors in changing the attitudes of a generation. Parents are responsible, too, and so are teachers. However great the part of other agencies, teachers must take a prominent place in directing humanity away from its habit of resenting the presence of other peoples on this earth.

All teachers may well be working toward this goal, and workers in many fields hold it as one of their major teaching objectives. It seems to me, however, that it is peculiarly a part of the work of geography teachers, for we alone deliberately set about to acquaint our students with the modern peoples of all parts of the earth. In studying these groups, one by one, we have inumerable opportunities to correct wrong impressions and to substitute admiration for dislike.

INTRINSIC VALUE OF GEOGRAPHIC STUDY

The very subject matter with which we work tends in itself to promote an attitude of sympathetic understanding. More than one adult can trace a change in his attitude toward foreign peoples to the study of geography. What are some of the ways in which this change in attitude is brought about? Doubtless you could suggest several from your own teaching experience—I shall present three that come from mine.

1. All too often, foreign places are merely spaces on a map, and their peoples do not seem real at all. So long as others remain so vague in our mind as to be phantom-like, their prob-

lems, their difficulties, their life seems unreal, and they matter little more to us than if they were on a neighboring planet or in the Land of Oz. Through reading and talking about the children, the young people, and the fathers and mothers of other lands, they tend to become real flesh-and-blood persons. The collecting of pictures, the perusal of guide books, the preparation of exhibits of products from other lands, and correspondence with the children of other nations—all help to correct this air of unreality. If you wish, the International Friendship League, 603 Boylston Street, Boston, will put you in touch with children of other lands. More than one million letters have been exchanged through their efforts.

2. A second way geography fosters understanding and good will is this—it shows quite clearly what natural handicaps other nations face, and the problems growing out of those handicaps, and so lays the background for an understanding of traits and actions not likely otherwise to be properly understood. We may, perhaps, have learned that vast areas of Southern Italy are blighted by decidedly unhygienic conditions, and that the people seem content with a very low standard of living. Such conditions become more intelligible, even though no less regrettable, when the child knows that nearly all of the land is too mountainous to produce much food, that a serious drought lasting several months occurs each summer, that malaria keeps a large part of the population half sick and causes thousands of deaths each year, and that this relatively poor land supports a population ten times as dense as that of the United States. Problems such as Southern Italy faces lie before many nations, and others equally serious await solution elsewhere. To learn the basic causes of these problems is to appreciate the difficulties under which the people work. As we study other peoples in their regional settings, as we note the circumstances under which their national peculiarities have developed, this question naturally comes to mind: "Is it not likely that we ourselves, had we lived in such a country, would have developed the same peculiarities?" Any child who has felt what the true answer must be, cannot remain uncharitable or intolerant.

3. Geographical study tends to foster international good will, moreover, by the light which it sheds on the world-wide interdependence of nations. A study of Cuba reveals how that island has depended on us for capital, managerial talent, and a market, and we on them for cane sugar. Egypt sends us her strong

cotton fiber to strengthen our automobile tires, and we send her petroleum, machinery, and wheat flour. Inumerable ways in which the United States and other nations are interdependent are revealed to us as we study geography—through the migration of Italians to our country, the investment of American capital in Chile, the invasion of our South by the Mexican boll weevil, the seasonal movement of water fowl between our country and Canada. Nations also borrow inventions, laws, and even religions from one another. Because of this flow of trade, people, ideas, etc., from one region to another, all are tied together in one great organic whole. Through their appreciation of the interpendence of regions, children are led to see how vitally dependent we are on others, and they on us, how much we need their cooperation and they ours. Mutual understanding, respect, and the will to cooperate will depend in part on our knowledge of our interdependence.

VITAL SIGNIFICANCE OF CAREFUL TEACHING

Few if any would question, I think, that the study of geography tends to foster international good will, but to secure a large return there must be purposeful teaching. Vicious methods may even breed prejudice and dislike. The story is told of one teacher who always spoke of the Eskimos as untidy, of the Germans as intemperate, of the Italians as lawless. Presumably the Americans had all of the virtues, in her mind. To secure the largest return in sympathetic understanding, we may well do at least three things: we should deal kindly and thoughtfully with differences, we should search untiringly for those traits which we hold in common with the people we are studying, and we may well hunt for achievements which we can respect and admire.

1. Differences interest children, and we must not ignore them, but we must avoid invidious comparisons with our own land and people. Moreover, we must try to see how these differences have come about, and not merely catalog and marvel at them—otherwise we may end in making others seem queer. It is fairly easy to detect and to correct, in a measure at least, the national or racial egotism which sometimes reveals itself in the geography class room. A certain teacher has long made it a rule never to leave unchallenged any description of a people as ignorant, inferior, or uncivilized. Invariably it appears that the pupil is thinking of just one way in which the people are back-

ward, and generalizing in a sweeping manner on the basis of that one item. Besides recognizing the unfairness of his generalization, he can usually be led to see, too, that there are reasons for the retarded condition which so impresses him, and that it does not denote "natural" inferiority.

In interpreting differences, moreover, we must not stop with pointing out physical causes; we must be willing to dig into the history of the region if need be. We can better understand the expansion of Japan into Manchuria if we know, not only that Japan lacks certain natural resources to be found in Manchuria, but also that the early history of Japan was one of warfare, that the military class has continued to hold a dominant place, and that Japan came to full nationhood too late to have a share in the partition of the tropical lands of the Eastern Hemisphere.

2. After a thoughtful, dispassionate study of differences, we may well look for likenesses, for ways in which the landscape, the modes of life, and the underlying customs and ideals are like our own. The motto of a well-known college, "God has created of one blood all nations of men," is of wider import than a narrow interpretation of the words would indicate. Men the world over are not only of one blood but of one humanity. Individually, we are likely to magnify our own peculiarities, our personal appearance, our profession, etc., and forget what we have in common with others. Similarly, as a nation we are inclined to see how we differ from other nations, and not to sense so clearly the ways—to me, the more fundamental ways—in which we are alike. Children, the world over, play ball and they like sweets, whether a piece of sugar cane in India or a lollypop in Illinois. Fathers struggle to make a living, mothers fight the little battles of the neighborhood and defend the welfare of their families against all manner of evil, and young people long for worlds to conquer. When a certain seventh grade group was studying China, a Chinese laundryman who had been an object of curiosity and aversion in the town became a human being to them for the first time. That teacher had been successful in making her children see that Chinese and Americans are truly of one blood. Moreover, she had clinched the objective I stressed in discussing the intrinsic value of geography in making peoples seem real—she not only made the Chinese real but she went further and made them real human beings like the children themselves.

3. A third guiding principle to follow in working for a large

return in sympathetic understanding for the hours spent on geography is this, that we teach our pupils to respect and to admire the people they are studying. An open road to teaching respect is furnished by the skills and the achievements of foreign peoples. The Eskimo boat, or kaiak, is a marvel; the painstaking terracing of the Italian hill farmer may well merit admiration. Even the retarded Australian bushman has his boomerang. To older pupils, the conversion of an area of sand dune and swamp, the Landes district of France, into a productive pine forest, the reclaiming of the margin of the sea bottom by the Dutch, and the transformation of Germany's sandy Baltic Plain into an area of fertile farms, are admirable achievements.

Moreover, we may well stress the contributions each nation had made to world progress in science, law, art, literature, music, in fact in all fields of human endeavor. Though far out on the margin of geography, there is ample reason for giving them some attention. Each nation has something, we may be sure, to entitle it to a place in the pageant of progress.

EDUCATED HEARTS

We have seen that the fullest return in good will from the study of geography depends on careful teaching, in which differences are studied with care, likenesses are clearly presented and adequately stressed, and achievements fully revealed. We must go a step further, and insist, in turn, that this kind of teaching requires a particular brand of teacher. It can be done best only by a teacher with an educated heart. Attitudes are catching as measles. If we are contemptuous of others, our attitude will reveal itself. Unconsciously, we will be severe in our judgments, we will slight the good points of others, we will allow our antagonism to enter into the quality of our voice.

How can we become teachers with a larger understanding of and more generous attitude toward mankind? Each must seek that goal in his own way, but a valuable suggestion is found in the advice given by a French physician to his medical colleagues. In stressing a point on which all patients agree—that they want and need a physician who is human and kindly, able to see their viewpoint—he advised young doctors to read widely from the great literature of all ages. By spending much time with the books which present the great common needs and qualities of humanity, one comes, he says, to a larger sympathy and wisdom in his dealings with others, thus developing a quality of

mind that seldom results from professional reading alone. If geography has become "professional reading" to us, so that we are no longer sensitive to its message of good will, we can do no better, I am sure, than to follow his advice. William Hazlett wrote years ago, "The study of the classics is less to be regarded as an exercise of the intellect than as a discipline of humanity."

THE CHALLENGE

Today, we find nations drawing within themselves, barriers springing up between them, naval armaments growing, and racial antipathies bursting forth like wild fire. The need for men to carry on the task of supplanting ignorance with knowledge, of displacing prejudice with sympathy born of understanding, is truly great. If, as we feel, the nature of geography gives us a strategic place in the fight against international strife and ill will, it likewise lays a great burden on our shoulders. It demands of us that we make the most of our opportunities, that we deal thoughtfully with the differences we find, that we search long for likenesses which reveal the common brotherhood of man, and that we clearly present the accomplishments and the contributions to world progress made by other peoples. Above all, it demands of us that we ourselves be possessed with the ideal of world-wide sympathy and cooperation, that from its fire we may kindle a similar flame in the hearts of our pupils.

SOME MEMBERS OF THE METER FAMILY

By Ross McConnehey

magnetometer	bolometer	dynamometer
variometer	ammeter	photometer
coulombmeter	odometer	electrometer
potentiometer	radiometer	micrometer
glarometer	thermometer	voltameter
wattmeter	spectrometer	pycnometer
hydrometer	lactometer	eudiometer
hygrometer	interferometer	manometer
voltmeter	calorimeter	sonometer
saccharimeter	galvanometer	refractometer
secohmmeter	spherometer	chronometer
cathetometer	comptometer	permeameter
cyclometer	barometer	polarimeter

Are you acquainted with these members of the Meter family? There are others but if you know all these you have a good start.

CLASSROOM TESTS IN BIOLOGY*

By P. W. Holaday
Shortridge High School, Indianapolis, Indiana

It has been impossible to adequately cover within the confines of a brief paper the two topics of types of tests and test construction and evaluation. Probably every summer school student and most persons who attend conventions at all frequently hear too much about the essay vs. the objective test, therefore this paper will confine itself to a brief discussion of the real uses and the proper evaluation of tests.

The first point is—when to test. It is a point to be answered by the individual instructor. Some feel it best to administer a test every week or even oftener, while others give them only at the end of the various report periods. The latter plan has certain disadvantages if the objective test is to be used. There are many types of activities in biology to be measured, with a different type of measuring device for each activity. It is difficult if not impossible to include all of these activities within a single test. It is confusing to the pupil to be obliged to jump so rapidly from one type of test question to another of quite different make-up. Also, best results are obtained in the use of any technique when a sufficient number of problems are given to provide a measure of reliability. This is not possible when only a few specimens of each type are presented in a test. The ideal test is made up of at the most four types of testing techniques, and preferably only three or two. If other techniques are to be used, if the types of things the various techniques measure are to be measured, more frequent tests should be given. They should be considered simply as written work, part of the daily recitation, and given fairly frequently. You ask, "What kinds of tests? Should they be essay or objective?" The objective test is far easier to grade, easier to justify to the pupil whenever a question of standing arises, and as you may decide before the completion of this discussion, easier to construct after the first year or two. There are portions of the subject of biology and of related sciences which cannot adequately be covered with the ordinary type of objective test, and an occasional essay test may be used to cover those portions. If you are using this type of test for the purpose of discovering how the pupil expresses himself, how he attacks a

---

* Read before the Biology Section of the Central Association of Science and Mathematics Teachers, Dec 1, 1933.

problem and how well he is able to coordinate his knowledge, be sure that you correct for those points. It is a common thing to find that an essay test, given with the avowed purpose of discovering the ability of the pupils to use the facts in their possession for the purpose of drawing deductions, is graded solely upon the final result and not at all upon the processes which were supposed to be the subject of the test. If you test solely for the result, well and good. Or if you test for the methods of expression, also well and good, but base the most of your grade upon the thing tested. It is well to check up occasionally the ability of children to use microscopes, to prepare cross-sections, to plan and carry out a project or to carry out any one of a number of activities connected with the successful conduct of a class in biology. These techniques are necessary and should by all means be a matter of deep concern to the instructor, and when grades are given on the *performance* the majority of the grade should be based upon the mechanics of the performance and not upon the result obtained by it.

These are essay types of test questions however, and the author is mainly interested in objective testing and its evaluation. In constructing an objective test, the first thought should be given to the result desired. If it is to be a simple recall of facts, a successful joining of related facts, the ability to take facts already given or previously memorized and from them deduce an important law of biology, it should be definitely settled first of all. The aim of the test determines to a certain extent the type of test items used, the other main factor being the length of time to be consumed in testing. A short test of five or ten minutes should not include more than one type of test item, a twenty minute test may use two, or in some instances three. Next, the facts to be included in the test should be organized, with a few additional items for spares. The number of items in the test is determined by the length of time for the test, the type of test item employed and whether or not the tests are mimeographed. A mimeographed test occupies less class time than a dictated one in most instances, and consequently more items can be covered within a given length of time. The number of items of each type of test technique which can be covered in, say, ten minutes will have to be worked out by the instructor, for tests and classes differ. Something has been done on this subject if one cares to consult Ruch[1] or other authority.

[1] Ruch, G. M. "The Objective or New-Type Examination." Scott Foresman, 1929.

After the facts to be tested are carefully selected, they should be translated into test items. Be careful of 'trick" questions. Pupils utterly detest a teacher whom they consider has broken faith with them by teaching a fact or theory and then testing minor exceptions to it. The same caution applies here as in the case of essay examinations. If the test is supposed to measure the pupil's ability to retain and to relate facts, do not test on the ability to watch out for every little shade of meaning which it is possible to wring out of an otherwise simple statement. Pick the major parts of the course for testing. Pupils won't remember it all anyway and you might as well leave them with the major portions safely stored up in their heads rather than with the major portions fairly well learned and a confused notion of what the rest is all about.

An instructor with several classes who are to be tested at two or more times may wish to divide his test into two or more tests of approximately equal difficulty, so that one group may be tested with one form and be unable to pass accurate information concerning the test to another group. The two forms are also useful in cases of make-up tests for absentees and flunkers. If two or more forms are to be made, a sufficient number of items should be provided to furnish material for all the forms desired. This should be split on a matching basis, selecting pairs of items of somewhat similar content and approximately the same difficulty and putting one in each form. It is probably better to use techniques other than the true-false question if alternate forms are to be provided, for this technique demands a very large number of questions to fill the time, and with its use the tendency of an instructor is to ask a number of unimportant details, simply because of the paucity of material. Go over all items at least twice, reading them aloud to yourself and possibly showing them to another instructor. Be certain that no other interpretation than the one you intend can possibly be read into the item. If you find this to be the case, re-word the question or transfer it to another form of testing technique. Arrange the items as well as possible according to difficulty, make directions and correction key and the job is done for the time being. If the test is highly objective, correction may be done in class or by monitors under your direction. Now comes the interesting part, finding out what the test has accomplished.

In making a test, one should not try to have the number of questions add up to one hundred or to any certain fraction of it.

Find out how much time may be allotted to the test, how many questions of the type you plan to use can be administered per unit of time, and you have determined the number of questions to use in the test. Forget percentages, at least until it is time to pass out grades. There is a fundamental difference between the theories back of grades on essay and on objective tests. Essay tests grade children on the basis of their closeness to an imaginary grade of 100%. 100% of what? Is it 100% of the work covered during the term, 100% of what the instructor himself knows, or 100% of what the child is able to learn? We'll hope it is neither of the two former speculations, and if it is the last named, some of the pupils receiving 50% and 60% should really receive 100%, for they learned all it was possible for them to learn. The objective test ranks pupils according to their respective abilities from highest to lowest. A test should be difficult enough that few or no perfect scores are made, and easy enough to obtain *some* response from everyone. After test grades have been ranked, distribute your A's, B's, C's, D's and E's according to the normal curve which applies so well to all other human activities. About four or five percent each of A's, and E's, twenty four or five percent each of B's and D's and the remaining group in the center with C's is the normal distribution. Those getting within a point or two of the next higher grade should ordinarily be included in the group above. You know your test and you know your class. If the test grades are remarkably high, give more A's and B's, that is, put your division lines lower. If the class makes grades which are too low, grade more toward the D's and E's. Experience has shown that the current practice in the correction of essay examinations is to grade a pupil on the basis of his past deeds or misdeeds about as much as upon the work he did on that particular examination. An habitual C student who bones up for an examination may get a B on a paper which is far better than the "A" paper turned in by a pupil whose former habits are more free from censure. If letters, which after all stand for percentages, are to be given, it is better to base the pupils' work more on its relationship to that of the rest of the class than on the basis of adherence to some rigid and pre-determined standard. In objective testing, it is not ordinarily possible with properly constructed tests to have even half of the class actually make a grade of 75% on the test. The reason for this astonishing statement is that the author feels that the bright student should be given sufficient leeway to prove

whether or not he is very superior to the rest of the class. This adds sufficient difficulty to the test that grades are low if considered in terms of percentages instead of in terms of placement in the class. If a test is given and several students make a score of 100%, which one of the group is the best prepared, and how do the others rank? Grades are intended to be used as incentives to encourage class work, but if a certain amount of effort will obtain the highest possible ranking, why strain any further?

Now the tests have been selected, constructed, administered, scored, and grades assigned, but the tests still remain. The question also remains, how well did this test work. The answer can be obtained swiftly and accurately, and some other benefits may be derived at the same time. Select several accurate and capable students to assist you, get some cross-hatch paper in large sheets, and score the tests over again. Arrange the tests in rank order, and have an assistant write down each students work on each item as "plus" or "minus" for correctly or incorrectly answered items. Your whole sheet then has three values. If you wish to compute measures of reliability, use a piece of the same cross-hatch, cut out alternate squares along one edge and use it to obtain each pupil's score on half the test. This figure may be subtracted from the total to give the score on the other half, or the checking key may be moved over a square and the second half counted. The correlation between these two columns of scores, stepped up by use of the Spearman-Brown formula, constitutes the reliability of the test. The reliability of individual test items may be obtained by comparing the percentages of correct responses on the item made by the highest and the lowest fourths of the class. On most objective tests, it is possible to measure accurately and easily just how well the test has been measuring and how much dependence can be placed on individual or class scores. A third measurement concerns the total percentages of correctness for each item. An item passed by only five percent of the class is of as little value as one passed by all of them. Both should be rejected for future use unless revision is possible. Incidently this analysis may indicate to you where you are placing too little or too much emphasis in your teaching.

One very good idea in test construction in biology or in any other subject is the keeping of test items. Each item should be written or typed on a filing card and each card keyed according to the portion of the subject covered and the types of technique

used. After the test has been given, the total percentages of correct scores on the item and its reliability may be written on the card. New items may be added to the collection from time to time as new ideas come along, and older items may be discarded or revised. You have at your finger tips a complete list of test items covering the entire course.

It is time to make a rather complete test on the relationship of plant and animal life. Here is the section of the items covering the field. It is desired to have two forms. Here for example are two items covering the same topic and with about the same percentages of correct responses according to the first two or three times of use although no measure of this factor has been taken the last time or so. Put one item in form A, one in B, etc. Both forms are now complete. Take each form, sort the questions according to the technique used, sort according to difficulty with the easiest questions first in each group, and the test is ready for mimeographing. Simple, isn't it, after you get started.

NEW PIANO HAS NO STRINGS AND USES ELECTRICAL AMPLIFICATION

Production has started on a piano with no strings. Instead of having lengths of wire to produce the tones, short slivers of steel only a few inches long are vibrated by electricity.

The new instrument, called a clavier, uses a piano keyboard to actuate tone production, in which the note produced is 90 per cent fundamental and only 10 per cent overtones, just the opposite of an ordinary piano. Tones are produced by plucking a steel bar which has been grooved to the proper tune. The almost inaudible tone thus caused is picked up by magnetic induction and passed through an audio-frequency amplifier.

The amplifier unit is specially designed, having a capacity of 30 watts, as contrasted to the two or three watts of the average radio amplifier. Thus the player has at command a tone ranging from a mere whisper to one balancing an orchestra, with little distortion or dilution. In the instrument the impact noise, sometimes audible in a piano, is filtered out, producing what is said to be pure tones, capable of blending with other tones because of the freedom from sharp edges of overtones and partials.

The piano was developed by Prof. Lloyd Loar after eight years' experimentation. He was an early experimenter in amplification of tones through electrical means, working with stringed instruments.

It is said that through use of ear phones the piano student may practise his lessons without disturbing anyone, tones being heard only by him. A turn of a dial enlarges the tone capacity, if desired. The piano of the future, employing the tuned sliver-of-steel method, will consist of little more than the keyboard, as the piano movement occupies only a few inches of space.

—*Science Service*

EASTERN ASSOCIATION OF PHYSICS TEACHERS

One Hundred Twenty-fifth Meeting

Arlington High School

Arlington, Massachusetts

Saturday, December 16, 1933

PROGRAM

9:30 Meeting of the Executive Committee.
9:45 Reports of Committees and Business Meeting.
10:30 Address of Welcome: Dr. Clarence H. Dempsey, Superintendent of Schools, Arlington.
10:45 Address: "Principles of Air Conditioning." Prof. Raymond U. Fittz, Tufts College.
11:30 Report of Apparatus Committee. Mr. Robert W. Perry, Malden High School, Chairman.
12:00 Address: "Electrons, Photons and Waves." Prof. Philip M. Morse, Massachusetts Institute of Technology.
1:00 Luncheon at Wyman's English Tavern, 430 Massachusetts Avenue, Arlington. Price 60 cents.

Our next meeting will be March 17, 1934, at Harvard. Spring meeting early in May at Worcester Polytechnic Institute.

OFFICERS OF EASTERN ASSOCIATION OF PHYSICS TEACHERS

President, LOUIS A. WENDELSTEIN, High School, Everett, Mass.
Vice-President, HOLLIS D. HATCH, English High School, Boston, Mass.
Secretary, WILLIAM W. OBEAR, High School, Somerville, Mass.
Treasurer, WILLIAM F. RICE, Jamaica Plain High School, Boston, Mass.

BUSINESS MEETING

Mr. Russell S. Bartlett of the Phillips Exeter Academy, Exeter, N.H. was elected to active membership.

Mr. Hollis Hatch reported on the progress of our exhibit in connection with the Boston meeting of the American Association for the Advancement of Science, and distributed tickets for the use of members and their pupils.

Pres. Wendelstein called attention to the meetings of the teachers of Science section of the A.A.A.S and said that members of our association were invited to attend them. He appointed the following delegates to represent us officially:—Mr. Wendelstein, Mr. Obear, Mr. Hollis Hatch, Mr. Rice, Mr. Miller, Mr. Packard, Mr. LeSourd, Mr. Arthur, Prof. Black, Mr. Cushing, and Mr. Goding.

Pres. Wendelstein also reported having received from Prof. Palmer, President of the American Association of Physics Teachers, an invitation for members of our association to attend their meetings in Cambridge, December 27 and 28.

The resignation of Mr. Emerson Rice was reported. Mr. Rice has been a member of this association continuously since 1896 and it was voted that the Secretary send him a letter of appreciation.

It was unanimously voted to extend a vote of thanks to those connected with the Arlington School Department who received us so hospitably today.

REPORT OF COMMITTEE ON COLLEGE ENTRANCE REQUIREMENTS

MR. BURTON L. CUSHING, *Chairman, East Boston High School*

REVISED RECOMMENDATIONS

Believing first, that the present syllabus contains too much material for a one year course in Physics and second, that recent developments require the addition of some new material, the E.A.P.T. recommends to the C.E.E.B. a complete revision of the syllabus. The association further urges that whatever topics are added, the net result shall be a considerable reduction in the total content of the syllabus.

We would make the following suggestions:

(1) That the syllabus be divided into two parts: (a) minimum essentials which should be included in all courses and (b) optional topics from which a choice could be made depending on the needs and equipment of different schools and localities.

(2) That some of the newer Physics such as cathode rays, ionization, the photoelectric effect, the principles of radio, or modern refrigeration be included in the optional topics.

(3) That the examination also be in two parts: (a) required questions on the minimum essentials and (b) a choice among questions to be based on either more difficult phases of the minimum essentials or the optional topics, there being a sufficiently wide range of choice so that a pupil who has had a good course in Physics should find enough questions on topics he has studied to make up the total required number in the examination.

(4) That a committee composed of representatives of the Colleges, the Private Preparatory Schools and the Public High Schools be appointed to make the suggested revision.

It was voted that we adopt this report and that copies be sent to the proper officials of the College Entrance Examination Board.

Mr. Cushing also reported that the C.E.E.B. had appointed a commission to consider the practicability of setting a comprehensive examination on a four years' continuous course in Science.

REPORT OF COMMITTEE ON MAGAZINE LITERATURE AND NEW BOOKS

MR. C. W. STAPLES, *Chairman, Chelsea High School*

BOOKS

Traveling Waves on Transmission Systems by L. V. Bewley. Wiley, 1933. 334 pages. Copy in Boston Library.

Theory of Thermionic Vacuum Tubes, Fundamentals—amplifiers, detectors, by Leon E. Chaffee. 1933 McGraw-Hill. 652 pp. Illustrated.

Cinematography and Talkies, by James R. Cameron and Joseph A. Dubray. 1933. Woodmont, Conn.; Cameron Pub. Co. 255 pages.

The Universe of Science, by Levy Hyman. A discussion of the scope, materials, and methods of scientific inquiry.

Heat, by James M. Cork. 1933. Wiley 279 pages.

Experimental Atomic Physics, by G. P. Harnwell and J. J. Lunngood. 1933. McGraw-Hill. 472 pp.

Introductory Acoustics, by G. W. Stewart. 1933. Van Nostrand. 200 pp.

The New Background of Science, by Sir James Jeans. An amplification of parts of the earlier book *The Mysterious Universe.* The Macmillan Co. 296 pages and index. $2.60.

TEXT BOOK

Mastery Units in Physics, by Clifford Holley and Vergil C. Lohr. J. B. Lippincott Co. 1932. $1.41.

While not published in 1933, the book is included in this report because it is not so well known in New England.

It is a very clearly written text book with an abundance of good illustrations a little different from the usual ones. It has the additional advantage of including directions for experiments at appropriate places in the text, thus combining the textbook and manual.

Special emphasis on molecular physics is noticeable throughout the book.

REFERENCES TO PERIODICAL LITERATURE

Astrophysics

"Amateur Meteor Photography," Peter M. Millman. *Popular Astronomy*, June–July, 1933. p. 298.

"The Carolina Bays. Are They Meteor Craters?" *Scientific American*. Begun in September number and continued in October number.

"Automatic Photography of the Sun's Corona," David Todd. *Popular Astronomy*. June–July 1933. p. 309.

Atmosphere

"Air Conditioning," *Scientific American*. August 1933. p. 63.

"The Aerial Conquest of Everest," Lieut.-Col. L. V. S. Blacker. *National Geographic Magazine*. August, 1933. p. 127.

"Le Second Vol au-dessus du Massif Himalayen." *L'Illustration*. May 20, 1933. p. 108.

"Deux Records d'Altitude." (Russian fliers.) *L'Illustration*. October 14, 1933.

Aviation

"Transoceanic Dirigible Service," Wolfgang Lambrecht. *The American Traveler's Gazette*. July-September 1933. p. 20.

"Making Planes Easy on the Ears." *Popular Mechanics*. November 1933. p. 722.

Electricity

"Protection Against Lightning." *Bell Telephone Quarterly*. July. p. 192.

"Sharper Sandpaper Made by 'Electrocoating'" *Popular Mechanics*. November. p. 646.

"Electric Furnace Welds Without Flame." *Popular Science Monthly*. October 1933. p. 45.

Heat

"Sunspots Greatest Existing Refrigerators." Henry Norris Russell. *Scientific American*. August 1933. p. 60.

Historical

"Un Grand Savant Français. Le Jubile d'Arsenval." *L'Illustration*. May 20, 1933. p. 98.

Hydraulics

"The Diablo Constant=Angle Arch Dam." *Engineering*. July 7, 1933.

"Les puits artesien d'Aulnay-sous-bous." *L'Illustration*. October 14, 1933. p. 234.

"Rare-Stamp Racketeers Thwarted by Black Light." *Popular Science*. Sept. p. 22.

"Un Wagon Radiologique." *L'Illustration*. October 21, 1933.

Light
"Photography Works for Industry," by Franklin Courtney Ellis. *Scientific American.* August 1933. p. 70.
"Magicians of the Laboratory." *Popular Mechanics.* September 1933. p. 386.
"Can You Believe Your Eyes?" (Illusions.) *Popular Mechanics.* September 1933. p. 394.
"Taking Unusual Photos with Pinhole Cameras." *Popular Mechanics.* September 1933. p. 428.
"Home-made Projector Throws Microscope Movies on Screen." *Popular Science.* September 1933. p. 42.
"The Spectrograph—A Master Detective of Science." *Literary Digest.* September 9, 1933.
"How Rare Gases Give Beauty to Lighting," by A. P. Peck. *Scientific American.* October 1933. p. 154.

Materials
"Stahl"
Illustrierte Zeitung. June 8, 1933.
Entire number given over to subject of steel, written and illustrated in usual thorough German manner.
"Work of the National Bureau of Standards on Industrial Material," by P. H. Bates. *Scientific Monthly.* August 1933. p. 174.
"Putting Matter to Work" *Technology Review.* November 1933. p. 47.

Meteorology
"Air Leaks in Polar Waste Hold Secrets of Coming Weather," by A. R. Boone. *Popular Science Monthly.* October 1933. p. 11.
"The Latest in Weather Forecasting." *Popular Mechanics.* September 1933. p. 346.

Molecular Physics
"Surface Tension," by Prof. W. C. Hawthorne. *Scientific Monthly.* August 1933. p. 149.

Philosophy
"Science Changes its Mind." Waldomar Kaempffert. *Forum and Century.* August 1933. p. 104.
"The Sciences and Society." "The Living Age." August 1933. p. 547.

Radio and Television
"Static Ahead," by Allen Raymond. (On growth of radio.) *New Outlook.* July 1933.
"Mosaic Television for the Home." *Popular Mechanics.* September 1933. p. 321.
"The Human-Eye Camera." *Popular Science.* September 1933. p. 11.
"Perfect Transmission and Reproduction of Symphonic Music in Auditory Perspective." *Bell Telephone Quarterly.* July 1933. p. 145.

Testing
"Tires Torn to Pieces in Tests for Safety." *Popular Science.* September 1933. p. 32.

Transportation
"The Iron Horse Goes Modern." *Popular Mechanics.* September 1933. p. 330.
"The Penn Electrifies," by J. V. B. Duer. *Scientific American.* October 1933. p. 170.
"King 'Rex' Rules the Ocean." *Popular Mechanics.* November 1933. p. 648.
"L'Automobil et le Torsume." *L'Illustration.* October 1933.

Practically the entire number given up to automobile improvements and touring by auto.

REPORT OF COMMITTEE ON CURRENT EVENTS

MR. J. P. BRENNAN, *Chairman, Somerville High School*

On the walls of the Hall of Science at the Century of Progress is inscribed this succinct history of science. Composed by Dr. Henry Crew who formerly occupied the chair of the History of Science at Northwestern University. It reads as follows:

Pythagorus named the Cosmos;
Euclid shaped Geometry
Archimedes Physics.
Xenophane's gazing on the heavens saw them to be one,
Copernicus placed central in that one our shining sun.
In the motions of the physical bodies Galileo beheld law.
Thence Newton and the principle of universal gravitation.
Democritus glimpsed the atomic theory of the structure of matter.
Dalton established it.

When in the nineteenth century Lamarck and Darwin formulated the great principle of organic evolution, the science of life was seen as a cosmic progression of nature.

The Century of Progress saw Oersted and Faraday set forth and Maxwell and Hertz advance the theory of electromagnetism.

Through the labors of Becquerel of the Curies and of Thompson to our own day are revealed fragile atoms and electrons.

Plank's quantum and Einstein's relativity theory open new epochs of science.

New evidence presented by Professor A. H. Compton of the University of Chicago and Dr. Thomas J. Johnson of the Bartol Research Foundation in Philadelphia seems to confirm the theory that the mysterious cosmic rays are positrons. Since the earth is a huge magnet it will draw to its poles electrified particles that fall within its field. Positive rays ought to come from the west and negative rays from the east. Basing their choice of locality on the mathematical conclusions of the Abbe Lemaitre and Dr. Vallarta of M.I.T., Drs. Compton and Johnson, working independently, went to Mexico and found that the greater part of the rays come from the west.

Working on an idea that came to him while reading Commander Ellsberg's book *On The Bottom*, Dr. Benjamin Bronson of the Noble Hospital in Westfield, Massachusetts hopes to relieve and perhaps cure some forms of deafness. It is the common experience of divers and of workers in the pressure chambers of tunneling operations that their hearing improved when they returned to normal atmospheric pressure. Now in some cases of catarrhal deafness the disorder seems to be due to the failure of the Eustachian tube to open and allow the air to reach the inner ear. With the tube closed it is difficult for the drum of the ear to vibrate, with the result that the bones of the middle ear gradually become locked together and deafness ensues. Work at Johns Hopkins has shown that many cases of apparent nerve deafness is due only to the inability of these bones to move. In such cases, the use of a pressure chamber similar to the decompression chamber of the diver is producing good results.

In Europe, dry cells are now being made with a bakelite top instead of a pitch top. The advantages of this method of sealing the cells are that it is cheaper, the bakelite does not crack and there is no hot pitch to affect the cells. There is also manufactured over there a flashlight that does not

require a case. The cells are fastened together and the bulb is screwed into one of them. When the cells are exhausted the bulb is unscrewed and the cells are thrown away.

A new lamp which utilizes glowing sodium vapor is being developed for street lighting purposes. They are being used in Holland and in England and lately a half-mile stretch of the new lamps has been installed in Schenectady. These lamps are highly efficient, giving three times as much light as a tungsten lamp of equal wattage. It is hoped that thoroughfares may be so brilliantly lighted by these lamps that the glare of automobile headlights will be eliminated.

Dr. Clarence H. Dempsey, Superintendent of Schools of Arlington, welcomed the Association to Arlington and spoke as follows.

THE PLACE OF SCIENCE IN EDUCATION

In 1898, Mr. Stockwell, then State Superintendent of Education in Rhode Island, said in an educational address that since he graduated from college he had been obliged to re-learn his chemistry three times on account of advances made in that field of knowledge.

Since then, even greater developments have occurred in all branches of science. New chemical elements have been discovered, many new products have been fashioned, new controls of forces have been achieved, new machines have been perfected—with the result that the modern scientific, technological age has re-shaped our whole mode of living.

Merely to mention by name a few recent phenomena is to flash a vivid picture of the progress of science and its import for life. Rayon, cellophane, T.N.T., bakelite, chromium, helium, gasoline engine, radio, photo cell, x-rays, neon, aviation, "talkies," robots, submarines, stratosphere, cosmic rays, protons, electrons, hydro-electric systems, and numerous other creations by man rather effectively dispute Solomon's assertion that "there is nothing new under the sun." Yet, these wonderful things have become commonplace, integral parts of our daily existence.

Similar evolution has been occurring in biology, astro-physics, medical science, hygiene, and other fields. There is a long roster of scientists—Pupin, Steinmetz, Burbank, Edison, Flexner, Curie, Einstein, etc., whose contributions since 1900 have added tremendously to man's knowledge and mastery of the material universe.

All this increases the scope and importance of the scientists' field of research and action. Already man's span of life has been substantially lengthened and its attainable content been tremendously enriched. His power is well-nigh limitless. Moreover, developments in science during the next fifty years will probably greatly surpass those of the past half century.

One corollary of all this is that science must occupy an increasingly prominent place in the education of modern youth.

One might liken our modern civilization to an infinitely complicated machine, or set of machines, which a group of men must learn to drive, coordinating and harmoniously timing their various sorts of service so that everything shall run smoothly and safely. It is a very different proposition from running a simple agrarian program or a guild system similar to that in vogue in Europe a few hundred years ago.

The requirements for skilful coordinated driving or control are many,

ethical, economic, social, hygienic, political, cultural, scientific, and because these requirements are not mastered and adequately observed, we suffer. By no means the least of these is a better knowledge and interpretation of science. This is your particular field.

To my mind there are two main objects in view for the science teacher. First there is the goal of scientific scholarship with all that it implies including the thirst for increasing knowledge. This does not mean that every pupil who takes a course in physics, chemistry, or biology must become a specialist. There is a big place for general science and superficial knowledge. But what is learned must be accurate, sound, and basic for such further achievement as the individual may desire. The scientific attitude of mind must be cultivated. It must be an open mind, logical, and acquisitive, so that blind alleys or false trails will not be followed. The attitude must be that of Ulysses:

> "to follow knowledge like a sinking star
> Beyond the utmost bounds of human thought."

The second goal is that of wise application. The science teacher has no less superb an opportunity than any other teacher to inculcate the ideal and love of service for one's fellow men. In some ways the opportunity is peculiarly happy in that it does not call for direct or indirect moralizing, but opens the door to worthy and gratifying achievement which brings increasing satisfaction in direct proportion to its worth for humanity.

If, as we believe, the best way to overcome an evil is by substituting some positive good, there is great opportunity for the science teacher to arouse and foster a positive creative interest in his realm that will go far toward eliminating unwise and unworthy pursuits and ideals.

The difference between the scientist and the teacher of science is fundamentally this—the scientist is a technician, pursuing primarily and somewhat impersonally the task of studying and manipulating materials; the teacher is a humanitarian, emphasizing the knowledge and functions of scientific achievement in relation to man's welfare and progress. Approaching and dealing with the subject in this manner, you will enable your pupils to gain the maximum personal and social values from their scientific studies.

Prof. Raymond U. Fittz of Tufts College presented a very interesting and authoritative address on the Principles of Air Conditioning. A quotation from Shakespeare (Julius Caesar, Act 1, Scene 2) showed that even in those days the results of lack of air conditioning were fully recognized. The problems of air conditioning concern themselves with (1) producing an adequate supply of air, (2) control of its temperature, (3) control of its humidity, (4) its purification, (5) a study of its ionic content. A factor not to be overlooked in designing plants is the heat given off by living bodies and lighting systems. Two branches of the problem are (1) to secure comfort and well being for human beings (2) to produce satisfactory conditions for industrial processes. A few of the many industries requiring air conditioning are confectionery, spraying automobile bodies, baking, brewing, textile and electrical. Prof. Fittz showed many slides, some illustrating the principles applied in air conditioning machinery, others showing its installation in a candy factory, a bakery, a dairy, and a theater. By means of still other slides he showed graphically how the various factors in air conditioning can be studied and some of the conclusions reached.

REPORT OF NEW APPARATUS COMMITTEE

MR. ROBERT W. PERRY, *Chairman, Malden High School*

Mr. Stanley showed a motor driven pump and accessories from the Chicago Apparatus Company. The pump produces vacua as high as .01 mm. of mercury and pressure from 5 lb. to 50 lb. per square inch. With this Mr. Stanley demonstrated (1) The freezing of water under a bell jar in a few seconds by its own evaporation as the pressure is lessened. An ingeniously arranged mirror made this visible to everyone in the room. (2) Use of the pressure in a blast lamp. (3) Application of measured pressure or vacuum to a definite area of rubber, paper and aluminum constituting the side of a closed vessel. (4) The guinea and feather tube. (a) electrical discharge as the air is being exhausted, (b) the falling of the metal disc and feather side by side.

Mr. Ford of the English High School, Boston, showed specific gravity experiments using a weighted bar immersed in two liquids one of which had exactly twice the density of the other.

ELECTRONS, PHOTONS AND WAVES

By PROF. PHILIP M. MORSE
Massachusetts Institute of Technology

If we are to believe some writers of "popular science," it would seem that modern physical theory has gone mystical. People write of light as being wave motion on one page and talk of it as corpuscular motion on the next. One eminent writer speaks of the electron as being a particle on Mondays, Wednesdays and Fridays, and a wave on Tuesdays, Thursdays and Saturdays. One gathers from various books that Science has finally divorced herself from Common-sense, and is out to make the most of her new freedom.

These books make exciting reading, but I fear the excitement is somewhat overdone. The revolution in scientific theory we are witnessing is not the first in history; nor is this the first time that new theories seemed at first to be contrary to common-sense. As a matter of fact, at the beginning of the eighteenth century there was another such argument as to whether light was corpuscular or wave motion.

It must have been very difficult for the scientists of that day to picture light as wave motion. Except in a very few and uncommon cases light behaves exactly as a stream of particles does: it travels in a straight line, it reflects or refracts at a surface, and so on. On the other hand the waves these gentlemen knew behaved in quite a different manner. They did not travel in straight lines, and did not cast definite shadows behind objects as light does. It must have been quite hard for them to picture that waves of extremely small wave lengths would cast definite shadows, and would behave very much as a stream of particles does. It was only after Young demonstrated the phenomena of interference that they were forced, reluctantly, to change their minds.

If light is sent through two narrow parallel slits placed close to each other it will behave quite differently than a stream of corpuscles does. Instead of finding two bright patches on a screen set beyond the slits, the patches being the projections of the slits, we find a whole series of alternate

bright and dark bands having no apparent relation to the size of the slits. It is impossible to explain these bands by the simple corpuscular theory, but the wave theory explains them easily, as we can see by looking at Figure 1.

The crests of the light waves are indicated by the lines in the figure. The light is a plane wave before it reaches the slits, but after it has passed through the slits it spreads out into semicircular waves if the slits are narrow enough. The bands observed on the screen are the results of the combination of the two semicircular waves. In those places where the crests of the two coincide, shown by the dotted lines in the figure, the two waves

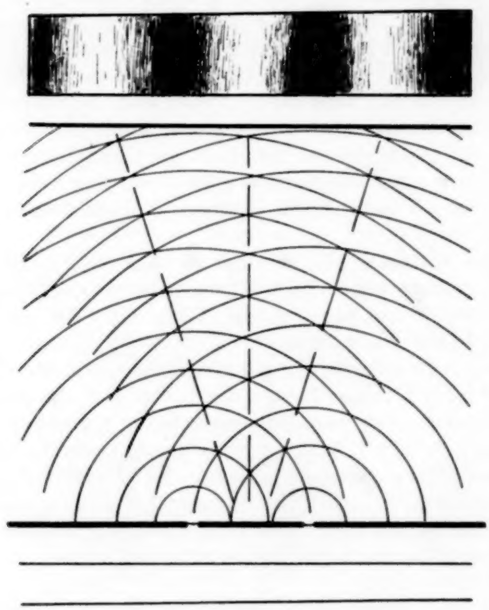


FIG. 1

reinforce each other and the light is brightest. Conversely, where the crest of one falls in the trough of the other, the two waves cancel and no light is seen. The result, as we can see, will be a series of bands alternately dark and bright, whose distance apart depends on the wave length of the light and on the distance between the slits.

Now it is impossible to explain by the simple corpuscular theory how two beams of light can unite to form darkness, as they do in the dark bands of this experiment; so the corpuscular theory had to be abandoned. Scientists must have abandoned it with regret, however, for the wave theory requires quite a strain on the imagination. It is quite a strain, for instance, to imagine waves without knowing what medium carries these waves.

This difficulty in imagining a reasonable sort of an ether to carry light waves never has been straightened out. Nevertheless to us now the wave

theory seems quite in keeping with common-sense. We have become inured to the strains put upon our imaginations. Theories have a faculty of becoming obvious if they are taught to us early enough and often enough.

The fact that we become inured to the difficulties of a theory should not bother us unduly. If we were not spared the mental readjustments forced on our predecessors, we could not make the next step in the progress of science. A new theory cannot take its proper place in the body of science until a generation has been brought up instructed in its ideas from the start, so that they are thoroughly at home with its methods.

In the last decade we have watched another scientific revolution, and we have been facing the need for a mental readjustment perhaps more profound than the one faced by Young's contemporaries. We have found that in atomic processes light behaves like a stream of particles (we call them *photons* now). When light shines on a substance it does not affect the whole material uniformly, as the wave theory would lead us to expect. Here and there throughout the substance atoms are suddenly disarranged as photons strike them, but the rest of the atoms stay completely undisturbed. The effects are very much like those of a shower of tiny bullets, and not at all like the effects of a wave. Light, it seems, in its ultimate essence must be corpuscular.

But this does not mean that we can go back to the old corpuscular theory for the explanation of light. The experiments of Young, proving that light is wave motion, are still true. Light must be wave motion—and yet it must be particle motion.

The dilemma is pleasing to the popular writers, but no self-respecting scientist would leave a theory in such a muddle. For the past five years all the big physicists have been busy hammering together a satisfactory explanation, and by now this structure is nearly ready to be opened for inspection. Some of its outlines are still obscured by scaffolding, and not all the plumbing has been installed, but its general plan is clear to us. We can say that it *is* possible for light to be both wave and particle motion; the difference between the two aspects is in our point of view, and not in the intrinsic properties of light.

This will be made clearer if we remember that the particle aspect of light only manifests itself when we deal with the effect of small amounts of light on individual atoms, and that the wave aspect is only noticeable when we deal with the effects of fairly large amounts of light on matter in bulk. The resolution of the dilemma is as follows: the photon particles produce the individual effects, and the wave is simply a probability wave, fixing the likelihood of a photon being present. It is only when we see the effects of a large number of photons that we can see the pattern which the probability wave requires.

We can illustrate this by an example. Suppose we set behind two parallel slits some sort of very sensitive photographic paper which shows blackness as soon as light strikes it. Let us first shine weak light through the slits for a very short length of time, so that only a very small amount of light gets through. The older wave theory would lead us to expect that the paper would show alternate bands of gray and white, the reverse of the pattern shown in Figure 1, since the parts receiving light will be darkened. The contrast between the light and dark part of the bands will be small,

because only a small amount of light has fallen on the paper, but the classical wave theory predicts that the whole interference pattern will be present.

What we actually find is something completely different, and is shown in drawing (a) of Figure 2. There are a very few black spots present, where individual photons have struck, and the rest of the photographic paper is untouched. There is no resemblance at all to the interference pattern demanded by the wave theory, and the spots are placed almost completely at random, like shot sprayed from an inaccurate shot-gun. This is the particle aspect of light.

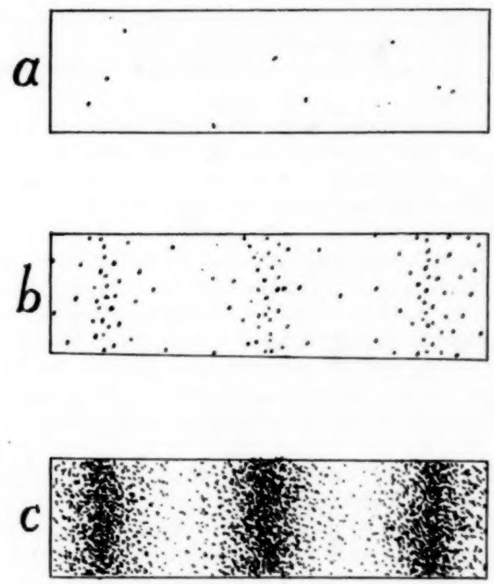


FIG. 2

Now we shall let a bit more light shine on the paper. The pattern in drawing (b) is still one of spots, where photons have struck, but now there is the beginning of a system in their distribution. The photons seem to be more likely to strike in certain places than in others, and with the larger number of spots we see indications of this preference. We also see that *the places the photons prefer are the places where wave theory predicts the greatest light.*

If we let still more light through we get a pattern as in drawing (c), still closer to the smooth pattern demanded by the earlier wave theory. The more light we let through the more nearly does the pattern look like that of Figure 1.

This, then, is the resolution of the dilemma. The photons are particles, but their preferences are guided by a wave: a wave of probability. It is somewhat hard to picture at first, but the ideas are no more difficult than those of the wave theory. The new theory really is a wave theory, with a

new definition of the nature of the wave. This new definition makes the wave theory also a particle theory, and perhaps renders meaningless the old question as to what carries the wave. Waves of probability may not need a medium.

The motion of each individual photon is unpredictable, but the average motion of large numbers of photons is quite predictable. It is at this point that most popular science writers make a graceful swan dive into metaphysics, and come up shouting about free will. I feel I had best refrain from following them, because I am no philosopher—at least, no better a one than most writers on popular science—and also because I feel that the new theory has nothing to do with free will. The probability waves are completely predictable, and the more photons one deals with the more predictable will be their congregate motions.

Instead, I will discuss briefly the other side of the theory, that concerned with matter.

Now that we have found that light is both wave and particle motion, it would be rather disappointing to find that electrons and protons are only particles. However nature is fair to us, and we find that although individual particles of matter behave like particles, the congregate motions of many such particles exhibit the properties of wave motion. The waves are again probability waves, determining the likelihood of the presence of matter. The wave motion is not the same as that of light, however, for light travels with the same speed (in vacuum) no matter what the wave length; matter waves of different wave lengths travel with different speeds. Also it turns out that most matter waves have a much smaller wave length than most light waves, which explains, why we have not observed matter waves until recently. The wave length is about as short as x-ray wave lengths.

The interference effects of electron waves have been observed many times in the last few years. The waves form interference patterns quite similar to those formed by x-rays when they are reflected from a crystal surface. The regularly spaced rows of atoms in a crystal forms a diffraction grating which produces interference patterns with both x-rays and electron rays.

There is another very interesting property of wave motion which has very important applications to the theory of radioactivity. We can illustrate it as follows. Light going through the prism in drawing (a) of Figure 3 is *totally reflected* at the upper surface. The photons bounce back from this surface like tennis balls from a barn door; Snell's law of refraction says that none of them can break through.

However if we put another prism next to this upper surface, as shown in drawing (b), then a certain amount of light will leak through the air gap barrier and travel out through the upper prism. An exceedingly small amount will get through if the gap is as large as is shown in the drawing, but if the air gap is made a thousandth of an inch thick or less, an appreciable amount of light will get through, even though there be no direct contact between the prisms anywhere.

This phenomenon violates Snell's law, and cannot be explained by the older corpuscular theory of light in vogue before Young's time. It is as though every so often our tennis ball would vanish as it struck the door,

and reappear inside the barn without having made a hole through the door! From the viewpoint of the new wave-particle theory, however, this last statement should not sound shocking. Waves, of course, are not as sharply defined as particles are, and a small part of the wave in the lower prism spreads over into the upper one, where it generates a wave going upward. Since the waves are probability waves the fact that a certain portion (say one hundredth) of the light comes out of the upper prism simply means that on the average one photon in a hundred disappears from the lower prism and appears in the upper one.

If this reasoning works for light particles it must work for material particles. Every so often an electron or proton will "leak through" a barrier which older theories would forbid them to penetrate. Radioactive elements are an example of this. The forces in an atomic nucleus can be likened in effect to a hollow metal sphere which holds the unfriendly

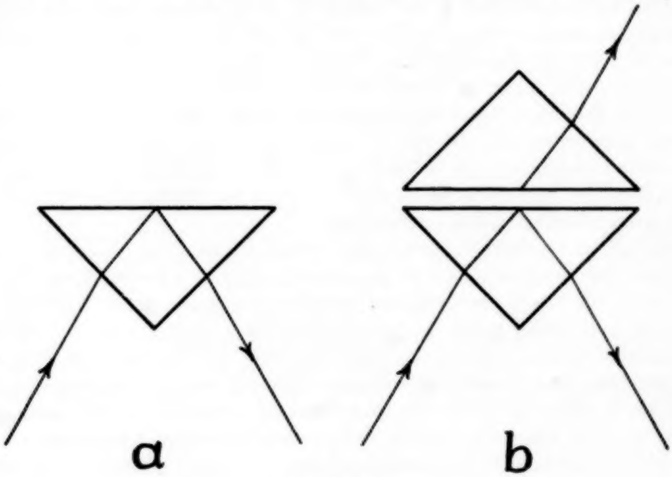


FIG. 3

nuclear constituents together inside it. In radioactive elements one or more of these component particles are bouncing back and forth against the containing walls of the sphere.

According to the older theories if the particle had enough energy to break through the wall, it would do so at the first bounce, and all the radioactive matter in the universe would have disintegrated as soon as it was formed. If, on the other hand, the particle does not have enough energy to break the wall, the older theory claimed that it would never get out. The new wave-particle theory disagrees with this last statement. It states that even though the particle does not have the energy to break the sphere, nevertheless some time or other, after countless millions of bounces, the particle will suddenly find itself outside the sphere and will fly off as a radioactive ray, leaving behind a new atom. Since the answers of the new theory are always averages and probabilities, we cannot predict the lifetime of any individual radioactive nucleus; but if we know the strength and thickness of the barrier sphere which holds the nucleus together we

can calculate the *average* life-time of any radioactive material. The experimental data check these calculations very nicely.

In a similar manner the new theory states that if we fire many particles at a nucleus, once in a while one of them will leak through the protective barrier into the inside of the nucleus, even though none of them are going fast enough to break a hole through the barrier. Usually when a nucleus finds an extra particle in its midst it blows up. Crockroft and Walton in Cambridge, England, have observed these nuclear explosions when 600,000 volt protons were fired at light atoms, although it would take protons with energies several hundred times this to actually break a hole through the nuclear barrier. The ten million volt electrostatic generator of Dr. van de Graaff at Round Hill is designed to make the penetration of nuclear barriers easier, and to produce nuclear disintegrations more efficiently.

No doubt the ideas of the new wave-particle theory seem strange and artificial to us now; but I am sure that their strangeness is due only to their newness and to the fact that we have been brought up on the older theories. To make the new theory seem familiar to us after having learned the old requires a mental revolution which is rather difficult. It is significant that the majority of the important developments of modern atomic theory have been made by men so young that they were studying physics while the new theory was developing, and so did not have to un-learn the older theories. Heisenberg and Dirac, two of the Nobel prize winners this year, are under thirty-five years of age.

Our job as teachers of physics is a manifold one. We must teach people the scientific method, the way a scientist looks at a problem, so that our students will begin applying our teachings in the fields of business, and politics, and social relations, where there is a crying need for scientific method. Of course we must teach our students the detailed facts of physics so that they can repair doorbells and automobiles. But perhaps our biggest job is to instil the facts and methods of physics into that small group of young men who are to be the next generation of great physicists. We do not know who is to be in this group, but it is likely that some of us here may have one or two of the group in our classes. It is important that we teach these people the essentials of the new theory early and often, so they will have nothing to un-learn, so that when they become great physicists they will be able to handle the new theory with ease and efficiency, and so that they will be able to go on to take the next step in the development of science.

SCIENCE QUESTIONS

February, 1934

Conducted by Franklin T. Jones, 10109 Wilbur Avenue, Cleveland, Ohio

Readers of School Science and Mathematics are asked to contribute: Questions, Answers, Comments, Suggestions—Whatever is new or interesting in the teaching of Science.

Wanted—Your mid-year examination papers. Thanks! Mail them.—Do it now.

ANOTHER SUGARING OFF-HUDSON—MARCH 17, 1934

641. *Proposed by Wm. G. Vinal, Nature Guide School.*

Dr. Joel Hayden, Headmaster of Western Reserve Academy, Hudson, Ohio, writes the "Science Teachers hereabouts" and their friends to meet in Hudson on Saturday, March 17, 1934:

Morning—A meeting of Teachers in the Old Chapel
Afternoon—In the Sugar Camp
Evening—Dinner and Entertainment.

(See article elsewhere in this number of SCHOOL SCIENCE AND MATHEMATICS.)

ANSWER WANTED

636. (Repeated from December, 1933.) *Proposed by the Senior Physics Class of the Norwich Free Academy, Harold Geer, Secretary.*

If from Norwich, Connecticut, a twelve-pound shot were dropped through the center of the earth; (*a*) where would it come out, and (*b*) what would happen to it on its journey?

THE SECRET OF LIFE

642. *Suggested by Annual Report of the Carnegie Institution of Washington, Dr. C. B. Davenport, Head Dept. of Genetics.*

1. What is the "Secret of Life"?
2. What is the "gene"?
3. Of what does the gene consist?
4. How large is the gene?
5. Can it be *photographed?* Why, or why not?

WHY THE FAILURES?

643. *W. F. Roecker, Milwaukee, Wis. submits an examination he has used several times.*

"My object was to draw up the easiest possible set of questions which would cover the ground and still separate the gold from the dross. I would like to know what is the matter with this examination because it invariably fails more people than it should."

Answer the first 25 questions with as few words as possible. Answer 5 of the last 6 questions as fully as possible.

Each short question counts 2 points; the last set of questions count 10 points each.

1. When a body displaces less than its own weight of liquid will it sink or float?
2. A 10-horsepower engine will do how much work in a minute?
3. Will an object weigh more or less in a vacuum than in air?
4. When a clock loses time should its pendulum be lengthened or shortened?
5. What is the mechanical advantage of a single movable pulley?
6. When a cubic foot of water is warmed 1 degree Fahrenheit how many Btu are needed?
7. The vacuum in a thermos bottle does not prevent heat transfer by ....
8. What is the reading of absolute zero on the centigrade scale?
9. A boat weighing 625 lb. displaces how much water?
10. The center of gravity of a vase is .... when flowers are put in it.

11. A lever 6 feet long has its fulcrum 6 inches from one end. What is its mechanical advantage?
12. How much work is done in pushing a 100-pound trunk 4 feet along the floor with a force of 40 pounds?
13. Define footpound.
14. A highway with a 2% grade rises .... feet in a mile.
15. State Archimedes' principle.
16. What is the atmospheric pressure when the barometer reads 27 inches.
17. 100 cubic feet of air under atmospheric pressure will assume what volume under a pressure of 300 pounds per square inch?
18. A ten-inch spring is stretched 2 inches by an 8-pound weight. How will 80 pounds effect it?
19. What will be the resultant when a force of 20 pounds north and one of 12 pounds south are acting on an object?
20. What is Invar?
21. The moment of a force is its effectiveness to produce ....
22. A liquid has a specific gravity of 1.8. Its density in the English system is ....
23. A compressed coiled spring has ....energy.
24. 98.6°C equals .... degrees Fahrenheit.
25. Drops of water are held to the window pane by the force of ....

---

1. A window is pushed up by a pole inclined 30 degrees to the vertical. If the force exerted along the pole is 12 pounds, what is the force pushing the window up?
2. A hockey puck starts on the ice with a velocity of 50 feet per second. If the friction with ice retards it 4 feet per second, how far will it go?
3. The lowest recorded temperature on the earth is minus 90 degrees F. and the highest is 136 degrees F. Express the difference between these temperatures in centigrade degrees.
4. A 4 horsepower motor attached to a pump has an efficiency of 75%. How many gallons of water can it pump per hour if the water is raised 45 ft.? One gallon of water weighs 8.4 lbs.
5. What force is required to hold a block of wood submerged if it weighs 150 lbs. and is 1 ft., by 2 ft. by 2 ft.?
   (b) Find the specific gravity of a metal casting that weighs 540 lbs. in air and 470 lbs. submerged in water.
6. Discuss the theory of heat. How do we explain melting, vaporization, and gas pressure?

WHY THE CHAMPION LIE OF 1933?

643. *Why is this a lie?*

This "whopper," submitted by B. Ceresa of Langeloth, Pa., was awarded the prize-winning medal given annually by the National Liars Club with headquarters in Burlington, Wis.

Ceresa's yarn was selected from 2,500 entries from 40 states, Canada, the Army and the Navy and he was acclaimed as the "First Liar of the Land."

The Champion Lie of 1933

"My grandfather had a clock that was so old that the shadow from the pendulum swinging back and forth had worn a hole in the back of it." (From press dispatch, Dec. 31, 1933.)

Here's another question.

Did the shadow of the swinging pendulum *protect* the back of the clock

from bombarding "light particles" so that it should have been better preserved where the shadow fell?

Answers desired from
Senior Physics Class, Norwich Free Academy.
Girls Science Club, Hawarden, Iowa.
"Packard's Physicists," Brookline, Mass.
Chemistry Class, Gilmer, Texas.

GUILD OF QUESTION RAISERS AND ANSWERS (GQRA)

Additional and New Members—February, 1934.
14. Wm. G. Vinal, Cleveland.
15 Wm. F. Roecker, Milwaukee.

PROGRAM OF THE MEETING OF THE COUNCIL OF SUPERVISORS OF ELEMENTARY SCIENCE

Cleveland, Ohio, February 24, 1934
Hotel Statler—Ballroom

President, Florence G. Billig, College of Education, Colleges of the City of Detroit, Detroit, Michigan.
Vice-President, W. G. Whitman, State Teachers College, Salem, Massachusetts.
Secretary-Treasurer, W. W. McSpadden, Supervisor of Sciences, Austin, Texas.

MORNING SESSION, 9:30 O'CLOCK

The Curriculum School as a Method of Building a Course of Study in Elementary Science. Anna Burgess, Principal, Doan School, Cleveland, Ohio.
The Science Program in the Elementary School, The University of Chicago. Bertha Parker, The University of Chicago, Chicago, Illinois.
The Science Program in the Public Schools of Austin, Texas. W. W. McSpadden, Supervisor of Sciences, Austin, Texas.
The Content and Organization of Science Syllabi as Judged by Experienced Teachers. Phillip G. Johnson, Teachers College, University of Nebraska, Lincoln, Nebraska.
A Program for the Extension of Work in Science Education. S. R. Powers, Teachers College, Columbia University, New York.

LUNCHEON, 12:00 O'CLOCK
Lattice Room, Hotel Statler

Guest Speaker, Dr. M. Luckiesh, Director Lighting Research Laboratory, General Electric Company, Nela Park, Cleveland, Ohio.

AFTERNOON SESSION, 2:00 O'CLOCK

Importance of Research in the Development of Science in Elementary Schools. O. W. Caldwell, Institute of School Experimentation, Teachers College, Columbia University, New York.
Bird Banding. S. Prentiss Baldwin, The Baldwin Bird Research Laboratory, Hillcrest Farms, Gates Mills, Ohio.
Camp Experience a Vital Part of the Equipment of a Teacher of Science in Elementary Schools. W. G. Vinal, School of Education, Western Reserve University, Cleveland, Ohio.
Annual Business Meeting of the Council.

BOOK REVIEWS

High School Chemisty, by George Howard Bruce, Department of Chemistry, Horace Mann School for Boys, Teachers College, Columbia University. Illustrated with drawings by Will H. Schanck and with photographs. Revised Edition. pp. x+550. 2.75×13.5×19 cm. Cloth. World Book Co.

This is real revision after a five year period of use. As those who are acquainted with the first edition well know one of the chief merits of the text is its clarity of expression and its use of a vocabulary familiar to pupils. Further revision looking toward still greater clearness has been brought about in this new edition and new material bringing the subject matter more nearly up to date has been introduced. A brief study of some of the chapters dealing with material that is hard to teach to beginners shows that the presentation is excellent. The application of the ionic theory and the study of dynamic equilibrium and conditions tending to disturb it, for example, are very well done.

High school chemistry teachers will be interested in studying the teaching method of this text.

FRANK B. WADE

The Universe of Light, by Sir William Bragg, Honorary Fellow of Trinity College, Cambridge; Fullerian Professor in the Royal Institution of Great Britain. Cloth. Pages x+283. 14+21.5 cm. 1933. The Macmillan Company, 60 Fifth Avenue, New York, N.Y. Price $3.50.

Can you explain to a high school student or to the man on the street why the sky is blue, or why the halo around the moon is sometimes larger than at other times? Why is the ocean blue? Why is the sun yellow or red at sunset? Why does the moon look large when near the horizon? What produces the brilliant color of a peacock feather? What makes a diamond sparkle? How is the temperature of a star determined? How do we know that the sun revolves?

These and a host of other questions relating to common phenomena are explained by the famous investigator, Sir William Bragg, in this entertaining book for the general reader. It is the type of book needed to supplement the high school study of light. Everyone is interested in artificial color displays or optical illusions as well as in the natural optical phenomena. This book describes many easy demonstration experiments used to introduce the explanations. Teachers will find many suggestions for enriching the regular class activities and for club or project work. Parents and other members of the family will want it; no equations, no technical discussions, many illustrative drawings, photographs, and beautiful color plates. It is without doubt the best book on light for the general reader that has been published.

G.W.W.

Great Men of Science, by Philipp Lenard, formerly Professor of Physics and Director of the Radiological Institute in the University of Heidelberg. Translated from the second German edition by Dr. H. Stafford Hatfield with a preface by E. N. da C. Andrade, Quain Professor of Physics in the University of London. Cloth. Pages xx+389. 14×21.5 cm. 1933. The Macmillan Company, 60 Fifth Avenue, New York, N.Y. Price $3.00.

In the preface to this book the author says, " . . . in the present work the object was to deal with the great investigators only. . . . " And far-

ther on, "The names of the most important and greatest investigators, around whom our whole account is grouped, . . . are chosen according to the originality and general importance of their work, according to the degree of inward and outward difficulty which . . . they had to overcome, and finally also according to the signs of intellectual greatness which we can recognize from the general character of their personalities." He decided to include no scientist who survived the World War but did make exception to Van der Waals and Crookes.

Sixty-six names appear in the table of contents. Many other investigators are mentioned and their contributions evaluated where it seemed important to discuss them in relation to the work of the sixty-six. The book shows that a vast amount of study and reading of original sources has been done. It indicates a sincere attempt to deal with each contributor in an impartial manner. The author exhibits unusual ability to understand the conditions, limitations, intellectual environment, and religious restrictions of the early investigators.

The title of the book might readily lead one to expect that the scientists were chosen from all branches of science, but the author has with just a little exception confined his attention to physical science. Even here many readers will meet with some surprises. Among the sixty-six greatest scientists of the past are some names almost new to many science teachers. For them the book will open up a new field of interesting and instructive reading. A number of names familiar to all teachers of physical science are not even mentioned; e.g. Henry, Rowland, Wollaston, Wroblewski, Tyndall, Ramsay, Rankine, Moseley. Are we to infer that these men do not even deserve honorable mention? But even though we may feel that the author has kept his attention too closely focused on the investigators of Central Europe, we must agree that he has produced a remarkable review of the progress of physical science from early learning down to the dawn of modern physics. When we finish the book we wish for a second volume to carry the story to the present day. G.W.W.

First Year Algebra, by H. B. Kingsbury, West Division High School, Milwaukee, Wisconsin, and R. R. Wallace, Calumet High School, Chicago, Illinois. Pages x+440. 1933. The Bruce Publishing Company, Milwaukee. $1.32.

The reviewer is pleased to see another text in algebra in which sets of equations are presented before the formal work on factoring. This arrangement allows factoring and fractions to be studied in the same semester. The reviewer would like to see the removal of parentheses, even when preceded only by a minus sign, treated as one form of multiplication (multiplication by -1) whereas this text treats it in the customary way as subtraction.

Since the book is written by high school teachers with experience in large high schools, it shows a knowledge of how pupils learn, which is quite a different thing from the way in which adults learn. An adult may be willing to study a topic, check his understanding of it by taking a test, restudy the topic to find his errors, practice to acquire skill, take another test to find how skillful he is, repeat the practice until he acquires the proper amount of skill, and then review at intervals to retain the skill. An adult may do all this, and there are high school algebras written on this assumption, but an experienced teacher knows that other devices must be used with a high school pupil.

The book contains an abundance of exercises, supplementary work, honor work for the better pupils, good cumulative reviews and tests.

J.A.N.

Experimental Optics, by A. Frederick Collins, F.R.A.S. Illustrated. Cloth. Pages xiv+318. 12.5×18.5 cm. 1933. D. Appleton and Company, 35 West 32nd Street. New York, N. Y. Price $2.00.

The author of this book is well known for his series of popular books on science, mechanics, aviation, games, and puzzles. The first three chapters of *Experimental Optics* describe the sources, transmission and theories of light and the behavior of the human eye as a detector of light. The next twelve chapters deal with the phenomena and characteristic behavior of light. The last chapter discusses the connection between electricity and light and elaborates on some of the theories advanced in the first section of the book. The author has inserted many personal experiences and sketches which help greatly to supplement the factual material. Many experiments are suggested, the majority of which can be performed without the use of expensive apparatus. Detailed instructions are given for the construction of most of the more simple optical instruments. The author's style of writing and his simple language appeal to the beginner. The individual interested in studying science at home will find this book very helpful.

LOWELL C. WARNER

PROBLEM DEPARTMENT

CONDUCTED BY G. H. JAMISON
State Teachers College, Kirksville, Mo.

This department aims to provide problems of varying degrees of difficulty which will interest anyone engaged in the study of mathematics.

All readers are invited to propose problems and to solve problems here proposed. Drawings to illustrate the problems should be well done in India ink. Problems and solutions will be credited to their authors. Each solution, or proposed problem, sent to the Editor should have the author's name introducing the problem or solution *as on the following pages.*

The Editor of the department desires to serve its readers by making it interesting and helpful to them. Address suggestions and problems to G. H. Jamison, State Teachers College, Kirksville, Missouri.

SOLUTIONS AND PROBLEMS

Note. Persons sending in solutions and submitting problems for solutions should observe the following instructions

1. Drawings in India ink should be on a separate page from the solution

2. Give the solution to the problem which you propose if you have one and also the source and any known references to it.

3. In general when several solutions are correct, the one submitted in the best form will be used.

EDITOR'S NOTE: Problem 1311 as submitted in the December issue is incomplete. The phrase "*N*, an integer" should complete the statement of the problem.

LATE SOLUTIONS

1265. *W. E. Buker, Leetsdale, Pennsylvania.*

EDITOR'S NOTE: A solution to problem 1203 is now offered for the first time.

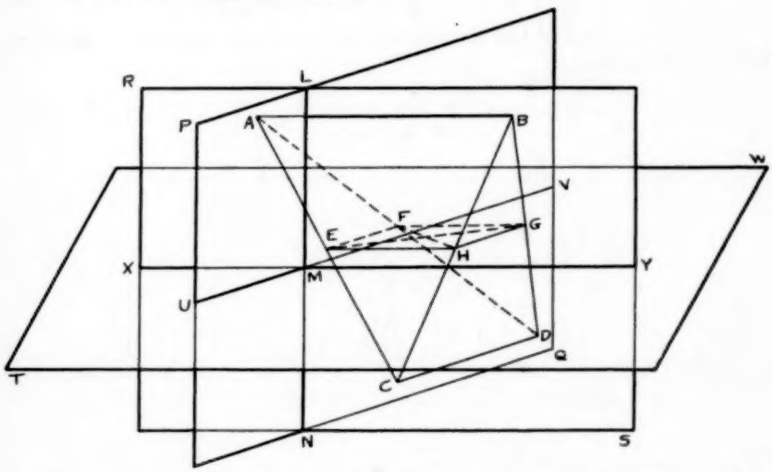
1203. *Proposed by Nathan Altshiller-Court, Norman, Oklahoma.*

The common perpendicular of two opposite edges of a tetrahedron is perpendicular to the lines joining the mid-points of the other two pairs of opposite edges of the tetrahedron.

Solved by Charles W. Trigg, Cumnock College, Los Angeles, Calif.

Given: Tetrahedron $ABCD$. Pairs of opposite edges AB, CD; AC, BD; and BC. AD. E, G, F, and H the midpoints of AC, BD, AD and BC respectively. Lines EG, FH, EF, FG, GH and EH.

To Prove: The common perpendicular to AB and CD is perpendicular to EG, FH, EF, FG, GH and EH.



Proof: Evidently the common perpendicular need not fall within the tetrahedron. Nor in the plane geometric sense could it be perpendicular to each of six coplanar lines not passing through a common point. Hence, in order to discuss the problem this definition is necessary: Two lines in space are said to be perpendicular if one of them is perpendicular to a plane containing the other. (If the lines do not intersect, this implies that a third line can be drawn in the plane through the foot of the perpendicular and parallel to the other line in the plane.)

In the $\triangle ABC$, $AB \| EH$.
In the $\triangle ABD$, $AB \| FG$. $EH \| FG$.
Through EH and FG pass the plane TW. $AB \|$ plane TW.
In the $\triangle BCD$, $CD \| HG$.
In the $\triangle ACD$, $CD \| EF$.
But HG and EF are in the plane TW. $CD \|$ plane TW.
Through AB pass the plane $RS \perp$ plane TW, and intersecting it in XY.
Through CD pass the plane $PQ \perp$ plane TW, and intersecting it in UV.
Since AB is not $\| CD$, plane PQ will intersect plane RS in LN.
$LN \perp$ plane TW at M.
$LN \perp UV$ and XY.
$AB \| XY$

$LN \perp AB$
$CD \parallel UV$
$LN \perp CD$
LN is the common $\perp$ of AB and CD.
Plane TW contains EG, FH, EF, FG, GH and EH. $\therefore LN \perp EG, FH, EF, FG, GH$ and EH.

Q.E.D.

1304. *Proposed by Howard D. Grossman, Brooklyn, N.Y.*

Prove that

$$\text{Prove that } \sqrt{2}=\frac{1+\frac{1}{3}-\frac{1}{5}-\frac{1}{7}+\frac{1}{9}+\frac{1}{11}-\frac{1}{13}-\frac{1}{15}\cdots}{1-\frac{1}{3}+\frac{1}{5}-\frac{1}{7}+\frac{1}{9}-\frac{1}{11}+\frac{1}{13}-\frac{1}{15}\cdots}.$$

Solved by Boris Garfinkel, Buffalo, N.Y.

The numerator and the denominator of the given may be expressed as definite integrals:

$$1+\frac{1}{3}-\frac{1}{5}-\frac{1}{7}+\cdots=\int_0 (1+x^2-x^4-x^6+\cdots)dx$$

$$=\int_0^1 (1+x^2)(1-x^4+x^8-x^{12}+\cdots)dx=\int_0^1 \frac{1+x^2}{1+x^4}dx$$

$$=\frac{1}{2}\int_0^1\left(\frac{1}{1+x\sqrt{2}+x^2}+\frac{1}{1-x\sqrt{2}+x^2}\right)dx$$

$$=\frac{1}{2}\int_0^1\left[\frac{1}{\left(x+\frac{1}{\sqrt{2}}\right)^2+\left(\frac{1}{\sqrt{2}}\right)^2}+\frac{1}{\left(x-\frac{1}{\sqrt{2}}\right)^2+\left(\frac{1}{\sqrt{2}}\right)^2}\right]dx$$

$$=\frac{1}{2}\sqrt{2}\left[\tan^{-1}(x\sqrt{2}+1)+\tan^{-1}(x\sqrt{2}-1)\right]_0^1$$

$$=\frac{1}{2}\sqrt{2}\tan^{-1}\frac{x\sqrt{2}}{1-x^2}\Big]_0^1=\frac{\pi}{4}\sqrt{2}. \qquad 1)$$

Similarly:

$$1-\frac{1}{3}+\frac{1}{5}-\frac{1}{7}+\cdots=\int_0^1 (1-x^2+x^4-x^6+\cdots)dx$$

$$=\int_0^1\frac{dx}{1+x^2}=\tan^{-1}x\Big]_0^1=\frac{\pi}{4}\cdot \qquad (2)$$

Dividing (1) by (2) we obtain:

$$\frac{1+\frac{1}{3}-\frac{1}{5}-\frac{1}{7}+\frac{1}{9}+\frac{1}{11}-\cdots}{1-\frac{1}{3}+\frac{1}{5}-\frac{1}{7}+\frac{1}{9}-\frac{1}{11}+\cdots}=\sqrt{2}.$$

Also solved by John E. Bellards, St. Nazianz, Wisconsin and Charles W. Trigg, Los Angeles, California.

1305. *Proposed by D. Moody Bailey, Belsprings, Va.*

A triangle and three cevians are given. Prove that the parallels to respective cevians through mid-points of the sides are concurrent.

Solved by Charles W. Trigg, Cumnock College, Los Angeles, Calif.

Given: $\triangle ABC$ with cevians AF, BD, and CE intersecting at R. G, H, and K the mid-points of AB, BC, and CA, respectively. $GM \| CE$, $HN \| AF$, and $KP \| BD$.

To Prove: GM, HN, and KP are concurrent.

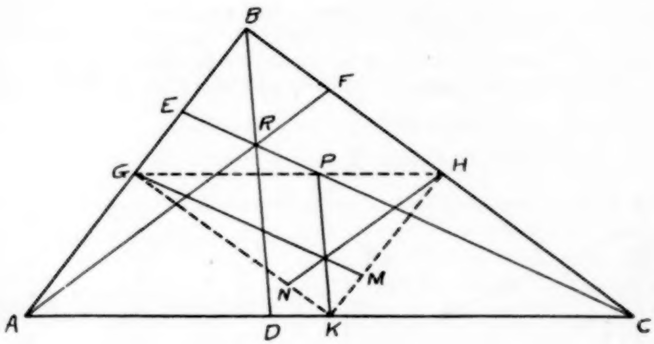
Proof: Draw GH, HK, and KG intersecting KP at P, GM at M, and HN at N, respectively.

Since they are the lines joining the mid-points of the sides, $GH \| AC$, $HK \| AB$ and $GK \| BC$.

In the following development, since their sides are respectively parallel, the pairs of triangles are similar and their corresponding sides are proportional.

$$\triangle KHP \backsim \triangle BAD. \qquad \frac{HP}{AD} = \frac{KP}{BD}.$$

$$\triangle GPK \backsim \triangle CDB. \qquad \frac{GP}{DC} = \frac{KP}{BD}.$$



Dividing equals by equals,

$$\frac{HP}{AD} \cdot \frac{CD}{GP} = 1. \tag{1}$$

$$\triangle HGM \backsim \triangle ECA. \qquad \frac{HM}{AE} = \frac{GM}{EC}.$$

$$\triangle KMG \backsim \triangle BEC. \qquad \frac{KM}{BE} = \frac{GM}{EC}.$$

$$\frac{KM}{BE} \cdot \frac{AE}{HM} = 1. \tag{2}$$

$$\triangle GNH \backsim \triangle CFA. \qquad \frac{GN}{CF} = \frac{NH}{AF}.$$

$$\triangle KNH \backsim \triangle BFA. \qquad \frac{KN}{BF} = \frac{NH}{AF}.$$

$$\frac{GN}{CF} \cdot \frac{BF}{KN} = 1. \tag{3}$$

Multiplying (1), (2), and (3) and rearranging the terms in the numerator and denominator of the left hand side of the equation;

$$\frac{HP\cdot GN\cdot KM}{GP\cdot HM\cdot KN}\cdot\frac{AE\cdot BF\cdot CD}{BE\cdot CF\cdot AD}=1. \qquad 4)$$

In the triangle ABC, by Ceva's Theorem,

$$AE\cdot BF\cdot CD=BE\cdot CF\cdot AD.$$

whence,

$$\frac{AE\cdot BF\cdot CD}{BE\cdot CF\cdot AD}=1. \qquad 5)$$

Substituting from (5) in (4) and clearing of fractions,

$$HP\cdot GN\cdot KM=GP\cdot HM\cdot KN.$$

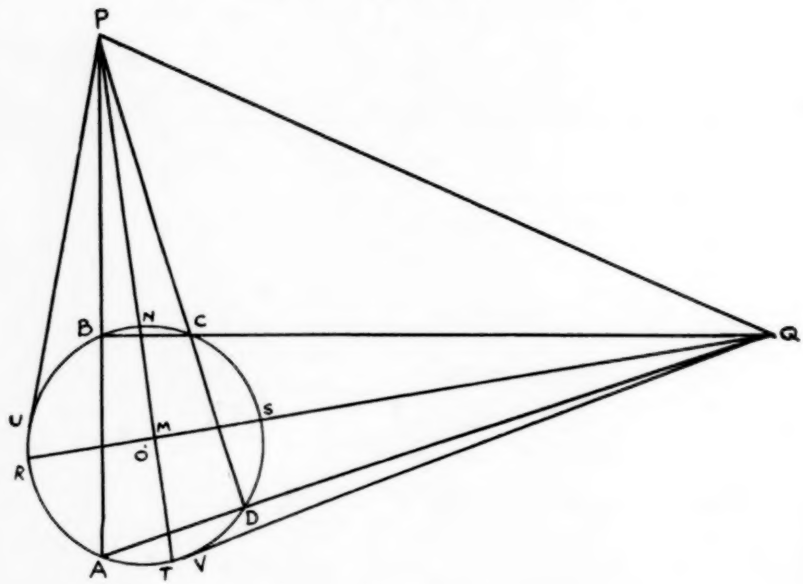
$\therefore$ By the converse of Ceva's Theorem, GM, HN, and KP are concurrent.

1306. *Proposed by H. G. Ayre, Waukegan, Ill.*

P is a point outside of a circle O from which the secants PBA and PCD are drawn. Q is another point outside the circle such that QCB and QDA are secants. PU and QV are tangents to the circle. Also PM and QM are the bisectors of angles APD and AQB respectively. Prove that

$$\overline{PQ}^2=\overline{PU}^2+\overline{QV}^2=\overline{PM}^2+\overline{QM}^2.$$

Solution by Herbert R. Leifer, Pittsburgh, Pa.



Let N and T be the points of intersection of PM and the circle, and S and R the points of intersection of QM and the circle.

Angle PMQ is measured by $\frac{1}{2}(\widehat{NS}+\widehat{TR})=\frac{1}{2}(\widehat{NC}+\widehat{CS}+\widehat{TA}+\widehat{AR})$

Angle QMT is measured by $\frac{1}{2}(\widehat{ST}+\widehat{RN})=\frac{1}{2}(\widehat{SD}+\widehat{DT}+\widehat{RB}+\widehat{BN})$

Angle BQR is measured by $\frac{1}{2}(\widehat{RB}-\widehat{CS})$ and angle RQA is measured by $\frac{1}{2}(\widehat{AR}-\widehat{SD})$, but angle BQR equals angle RQA, therefore $\widehat{RB}-\widehat{CS}=\widehat{AR}-\widehat{SD}$.

Similarly $\widehat{DT}-\widehat{NC}=\widehat{TA}-\widehat{BN}$.

Adding $\widehat{RB}-\widehat{CS}+\widehat{DT}-\widehat{NC}=\widehat{AR}-\widehat{SD}+\widehat{TA}-\widehat{BN}$.

Transposing $\widehat{RB}+\widehat{DT}+\widehat{SD}+\widehat{BN}=\widehat{AR}+\widehat{TA}+\widehat{CS}+\widehat{NC}$.

Therefore angle PMQ equals angle QMT and each is a right angle. Thus in right triangle PMQ, $\overline{PQ}^2=\overline{PM}^2+\overline{QM}^2$.

P and Q are conjugate points with regard to circle O. (If from a fixed point two secants are drawn to a circle, and their extremities connected in pairs, the opposite connectors intersect on the polar of the point.—Johnson, *Modern Geometry*, p. 102)

$$\overline{PQ}^2=\overline{OP}^2-r^2+\overline{OQ}^2-r^2.$$

(The square of the distance between two conjugate points equals the sum of the powers of the points with regard to the circle.—Johnson, *Modern Geometry*, p. 105).

But in right triangle POU, $\overline{OP}^2-r^2=\overline{PU}^2$, likewise $\overline{OQ}^2-r^2=\overline{QV}^2$. Therefore $\overline{PQ}^2=\overline{PU}^2+\overline{QV}^2$.

Also solved by the proposer.

1307. *Proposed by E. C. Kennedy, Austin, Texas.*

If a rubber ball rebounds to one-half the height from which it has fallen, how long will it take it to come to a complete rest if the initial fall was 48 feet?

Solved by Richard Wolfe, Lewis and Clark High School, Spokane, Washington

The sequence of successive falls is: 48′, 24′, 12′, 6′, · · ·

For a body freely falling from rest, ignoring air resistance $t=\sqrt{2S/g}$, taking g equal to 32 ft./sec./sec. The following sequence is obtained:

$$t_1=\sqrt{\frac{2\cdot 48}{32}}=\sqrt{3},\qquad t_2=\sqrt{\frac{2\cdot 24}{32}}=\sqrt{3}\sqrt{\tfrac{1}{2}},$$

$$t_3=\sqrt{\frac{2\cdot 12}{32}}=\sqrt{\tfrac{3}{4}},\qquad t_4=\sqrt{\frac{2\cdot 6}{32}}=\sqrt{\tfrac{3}{4}}\sqrt{\tfrac{1}{2}},\ \text{etc.}$$

These terms denoting the time for each fall are in geometrical progression with $r=\sqrt{\frac{1}{2}}$. Hence

$$T_\infty=\frac{a}{1-r}=\frac{\sqrt{3}}{1-\sqrt{\frac{1}{2}}}=5.913 \text{ seconds.}$$

Doubling, to account for the successive *rises*, $T=11.826$ seconds.

Subtracting the time of the first rise, which is not included, then $T=10.094$ *seconds*, time for the ball to come to rest.

If $g=32.16$ ft./sec.,^{2} then $T=10.070$ seconds.

Also solved by Kate Bell, Spokane, Washington; Joseph L. Stearn, Washington, D.C.; Charles W. Trigg, Los Angeles, Calif.; Ernest Oberbillig, Moscow, Idaho; John E. Bellards, St. Nazianz, Wisconsin; W. E. Buker, Leetsdale, Pa.; Harlan Rayburn, Petaluma, California and the proposer.

HONOR ROLL

1302. *H. Hansen Smith, Battle Creek Iowa, and John E. Bellards. St. Nazianz, Wisconsin.*

1307. Jay Jordan, Richard Wolfe, and a student who failed to sign his name, all from the Lewis and Clark High School, Spokane, Washington.

EDITOR'S NOTE: The following paragraph from a letter from Miss Kate Bell, the Lewis and Clark High School, Spokane, Washington may prove suggestive to other high school teachers. "I am glad you are continuing your honorable mention for work done by high school students. I post the names of our students who have won such mention and it is an incentive to other students to undertake this type of work."

PROBLEMS FOR SOLUTION

1322. *Proposed by W. E. Buker, Leetsdale, Pa.*

Prove that the area of a quadrilateral with given sides is a maximum when it is inscriptable.

1323. *Proposed by Charles P. Louthan, Columbus, Ohio.*

Two parachute jumpers, A and B leap from their air planes at the same instant. A is a feet and B is n feet $(a>n)$ above the ground. Assuming that the air resistance before the parachutes open is negligible and after their parachutes are open, they drop at a uniform rate of r feet per second, determine the altitude at which A's parachute must open so that both reach the ground simultaneously.

cf #1272 !!

1324. *Proposed by Clyde Rosser, Gaston, Oregon.*

If two tangents are drawn to a circle from an external point, then the distance from any point on the minor arc to a chord of contact is the mean proportional between the distances to the two tangents from the same point.

1325. *Proposed by A. Wand, Glendale, Missouri*

Bisect the area of any quadrilateral by a line passing through a given point in one of its sides.

1326. *Proposed by a Reader.*

If the sides of a triangle are in arithmetic progression, having a common difference of one, find the sides and angles, if the largest angle is double the smallest.

1327. *Proposed by G. W. Smith, Alta, Oklahoma.*

Solve $X^2+Y^2=13$
$X^3+Y^3=35$

PLANTS' STORED FOOD USED ONLY FOR GROWTH IN LENGTH

Food stored by a tree or shrub in its woody parts is subsequently used for growth, but only for growth in length—the formation of new shoots and leaves. It is not used to increase the thickness of the trunk or branches. Growth in thickness is accomplished only from food that has been made in the leaves a short time before.

This discovery was announced before the meeting of the American Society of Plant Physiologists by Dr. W. E. Loomis of Iowa State College at Ames. Woody plants do not grow thicker in spring until they have developed their leaves, Dr. Loomis said; and such growth in thickness can be stopped at any time in the season by stripping off the leaves or cutting off the lines of transport of food from leaves to trunk.—*Science Service*

HEAR YE! TEACHERS OF CHEMISTRY AND PHYSICS

In order to carry into effect the suggestions made by two prominent science teachers, Dr. B. Smith Hopkins, Illinois University and Dr. Arthur L. Foley, Indiana University whose papers will be found elsewhere in this issue, a committee was formed consisting of Dr. A. F. McLeod, Chairman, Dr. B. Smith Hopkins, Mr. E. E. Burns, Dr. John C. Hessler, Mr. M. J. W. Phillips, Mr. John H. McClellan, Mr. Raymond E. Whitney. The first duty of this committee is to collect information on the present practice in science teaching. This committee asks all high school teachers of physics or chemistry to answer the following questions at once and mail answers to the editorial office of this journal. Address School Science and Mathematics, 7633 Calumet Avenue, Chicago, Ill.

I. a. Do you have a double laboratory period? ____________

b. If so, how many per week? ____________

II. a. Do you have a single laboratory period? ____________

b. How many per week? ____________

c. If so, of how many minutes duration? ____________

III. a. Do you favor a single or double laboratory period? ____________

b. Why? ____

Signed ____________________

Teacher of ____________________

School ______________ **City** __________ **State** ________